AVTOMATIC CVT-OFF ENGINES

FOR ELECTRIC LIGHTING
ELECTRIC RAILWAYS AND
GENERAL MANVFACTVR-
ING PLANTS

BVILT BY

THE BALL ENGINE COMPANY

ERIE, PA. V.S.A.

REPRESENTED BY

D'OLIER ENGINEERING CO.,

129 SOUTH 11TH ST. PHILADELPHIA, PA.

OMATIC CUT-OFF

FOR ELECTRIC LIGH
ELECTRIC RAILWAYS AND
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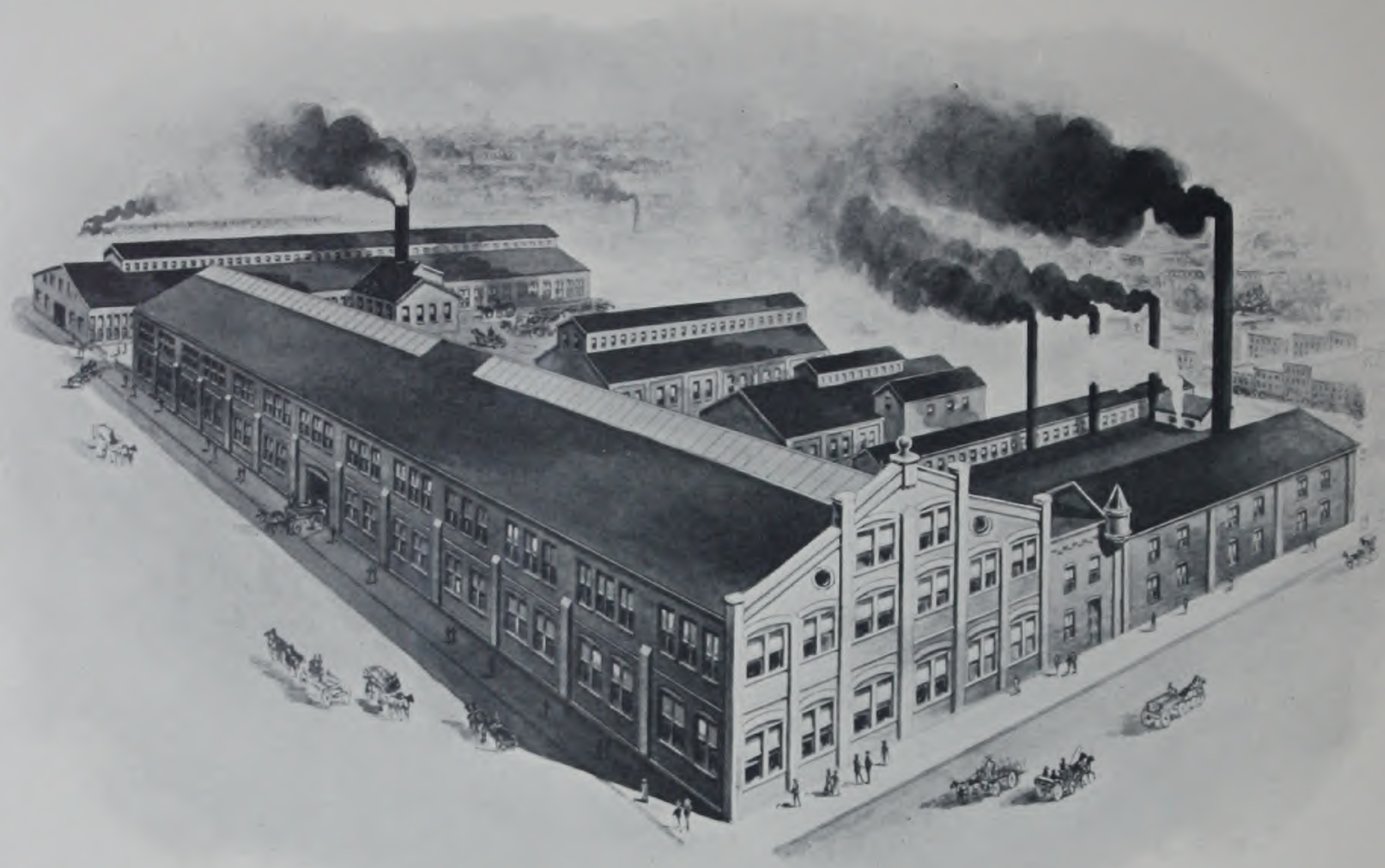
HE BALL ENGINE CO

ERIE, PA., U. S. A.



INTRODUCTORY.

FIFTEEN years of arduous service attest the superiority of our engines. During this time thousands of electric light and power plants in the United States and in foreign countries have put the products of our establishment to the severest tests; and for this reason we believe that the statement is justified that no other engines in this service have proved as efficient.

Our motto is that merit is the supreme test, and we have, therefore, continued to make such improvements as our extended experience and the requirements of modern electric lighting have suggested. We have increased the facilities of our many departments, extended our lines, and adopted the advanced methods of superior mechanics, which, combined with skill and a systematic method of manufacture, enable us to build an engine that for general merit we believe is unexcelled. Quality, rather than low cost, has been our aim.

It is obvious that the wide range of steam application for power-generating purposes necessitates modifications in the mechanisms for transmitting that power; and the properly equipped steam-engine building plant should be prepared to meet every possible demand on the part of the users of power. Intending buyers are assured that we can meet the most advanced requirements.

As indicative of the wide range of service for which we have special adaptations, we briefly refer to those types of engines for which there is a general demand, and to the various classes of duty for which they are peculiarly adapted.


AWARDED
NEW ORLEANS

Electric Lighting.

The temporary stoppage of the motive power of an ordinary manufacturing plant entails inconvenience only to the establishment itself; but the disability of an engine developing power for an electric light plant causes not only a loss in money and reputation to the company, but annoyance, inconvenience, and danger to the dependent public. The disabling of an electric light engine for only a short time may easily amount to more than the difference between the first cost of a high-grade engine and a cheap one.

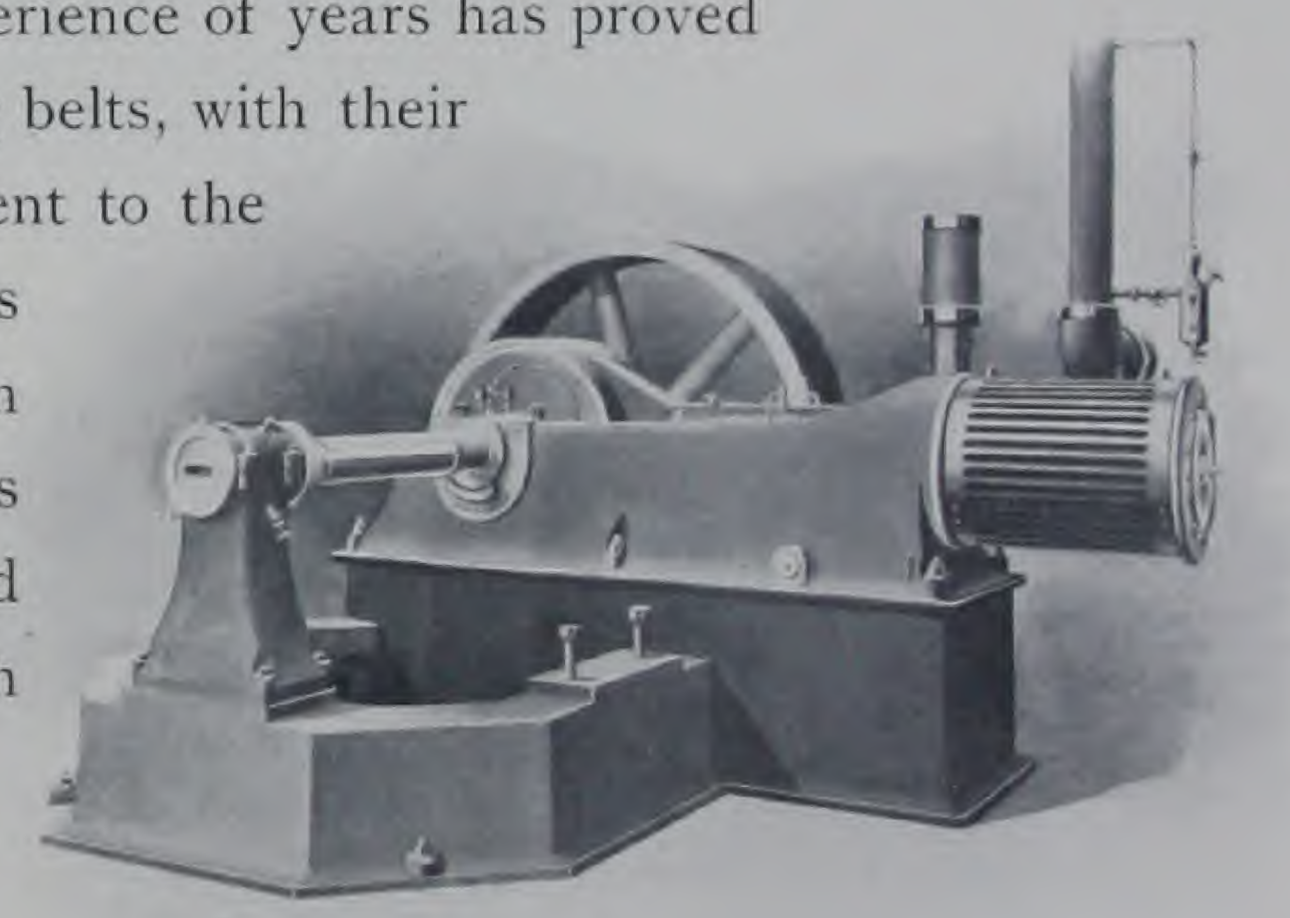
It is of vital importance that an engine for this purpose should be strictly first-class in design, material, and workmanship, as its durability and reliability depend on those points. No service demands such close, quick, sensitive regulation, and the governor must be one that gives practically the same speed under all conditions.

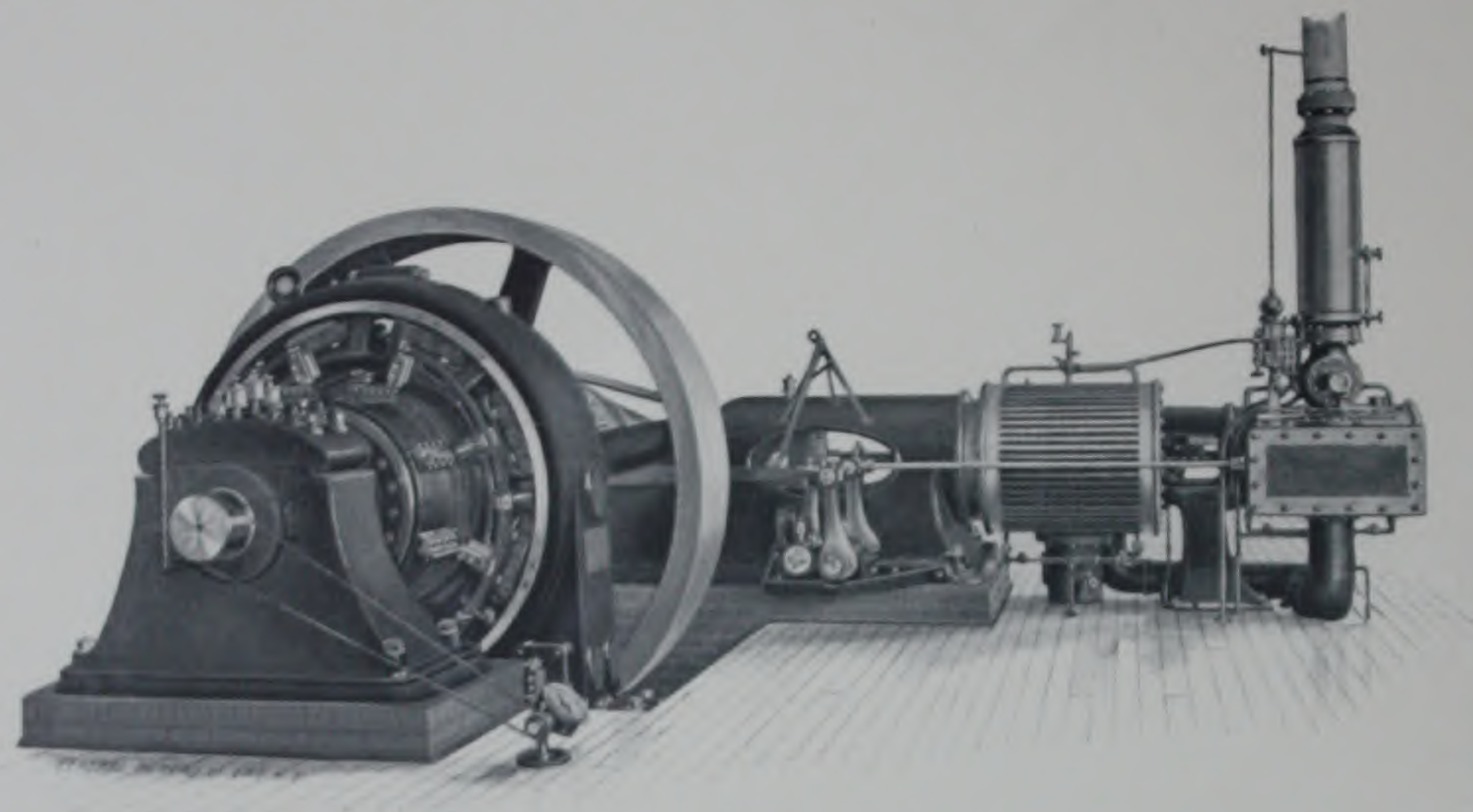
No stronger argument in favor of our engine could be advanced than this: that it is universally employed for this purpose, and has been the standard for years by which merit, economy, and usefulness are determined.

Direct Connection.

Direct connection of the dynamo to the engine is becoming more and more in favor, but this is accomplished successfully only by high-grade and perfectly governed engines. Our engines are especially adapted for direct connection, and are in use in many of the most prominent buildings in this country. We take pride in referring to two recent installations, the new Congressional Library at Washington and the new Public Library at Chicago.

That direct connection has tangible advantages admits of no question. The experience of years has proved this. Less floor space is required for a plant of given energy; heavy rapidly running belts, with their attending noise, are done away with; there is a saving in power consumption incident to the discarding of belts, and entire elimination of the friction occasioned in the journals of the pulleys carrying them. The annual saving in oil for journals, and repairs upon and care for the belts, form a not insignificant item; the concentration of apparatus reduces the probability of breakdown because permitting and assuring better and quicker attention of those in charge; and, finally, in localities where room is of high





MEDIUM SPEED, SIDE CRANK, TANDEM COMPOUND ENGINE.

DIRECT CONNECTED.

value, as in modern buildings in our great cities, direct connection is a necessity, and not a matter of preference.

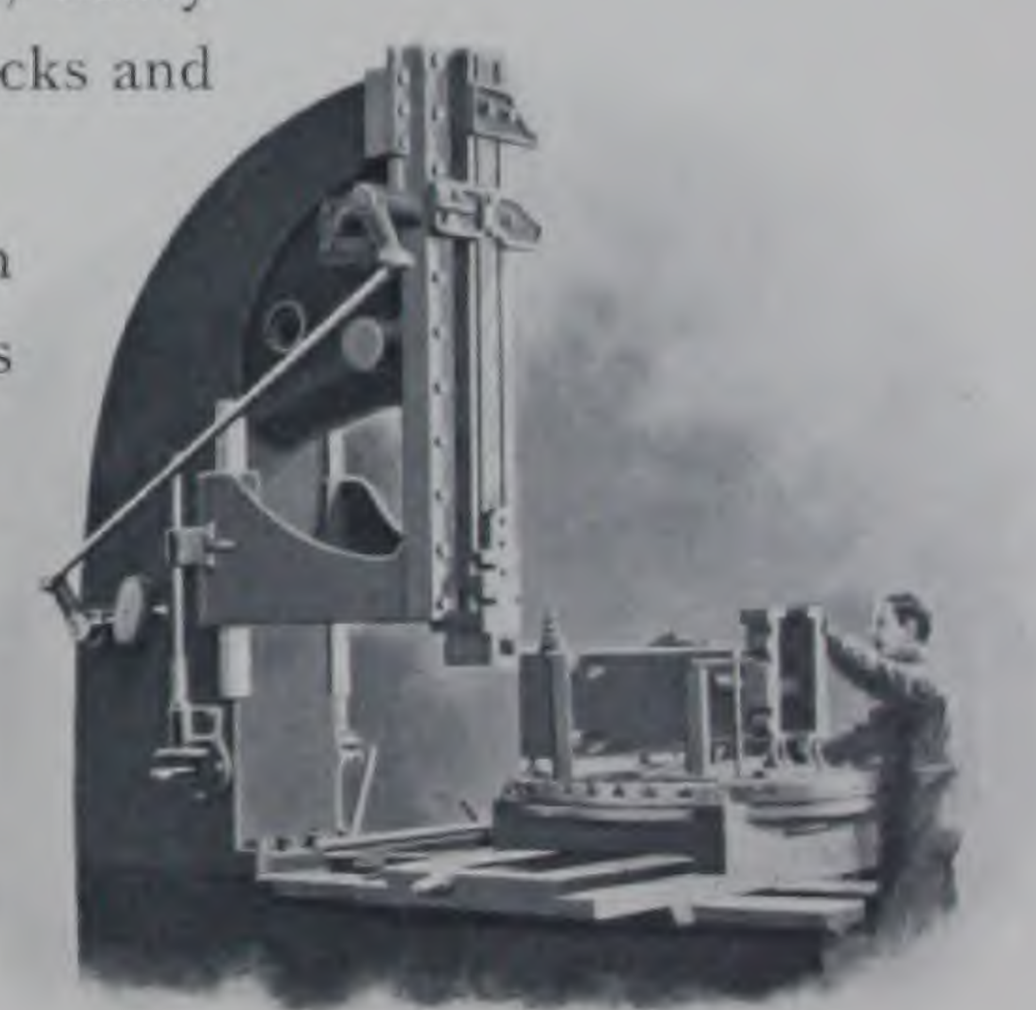
We have been singularly successful in this field, invariably meeting every requirement of location and service satisfactorily, and with dynamos of every reliable make. The noiselessness, cleanliness, and handsome appearance of our engines, combined with their extraordinary durability, freedom from repairs, economy, and fine regulation, has led to their use in many of the handsomest public and office buildings in the United States. The varieties of application of direct connection are getting to be very numerous. We illustrate a few of the standard types as examples.

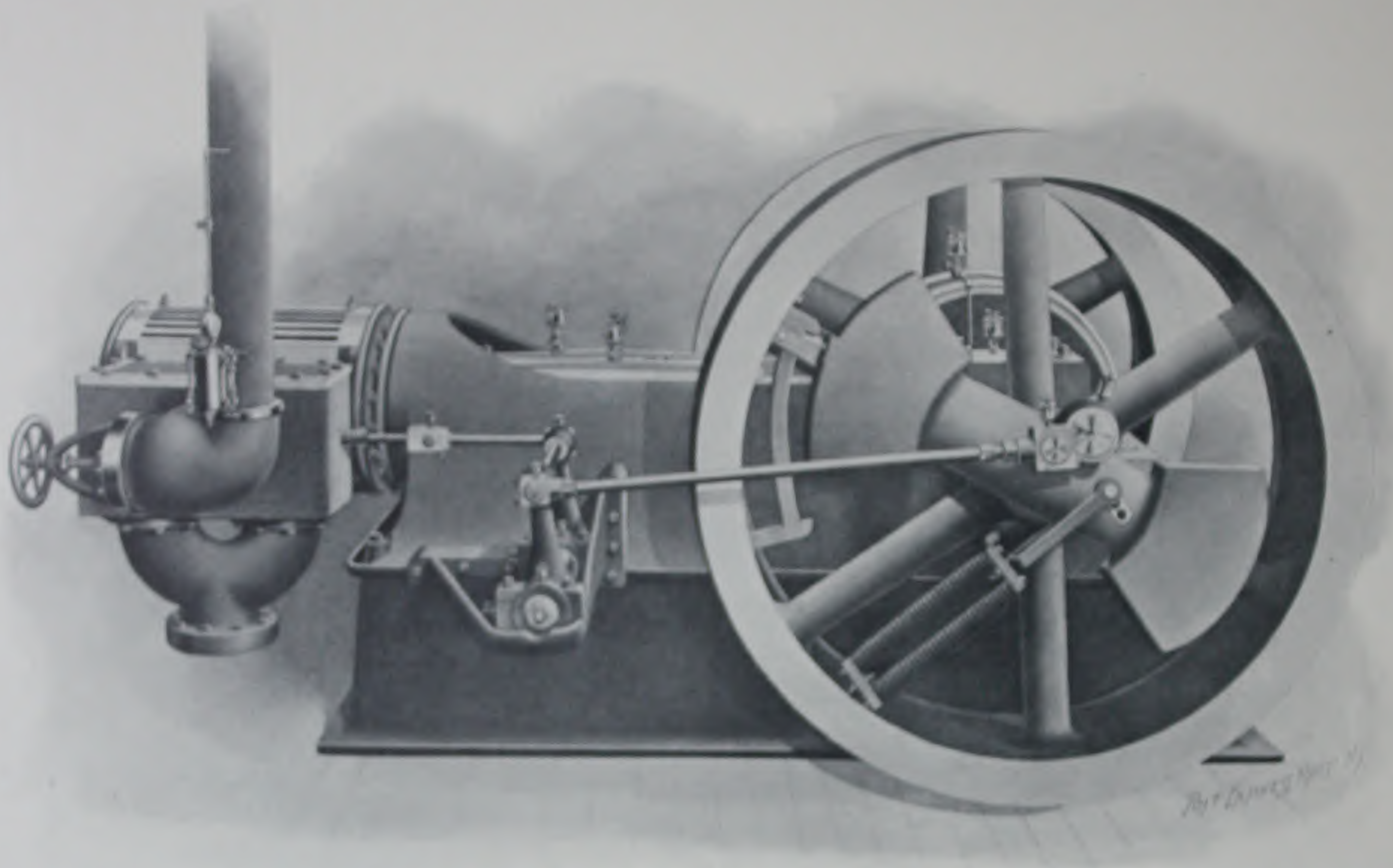
Electric Railways; Electric Mining.

The variability in the load imposed upon engines doing duty in electric railways and mining has made weakness in other forms of construction apparent, and this to so marked a degree that in many cases condemnation has quickly followed their installation; and where attempt to continue them in service has been made, absolute breakdowns of the engines have been the result.

Our engines have demonstrated, and are to-day demonstrating, their entire adaptability to this severe service. Our improved heavy duty engines, designed especially for this onerous duty, with stout, heavy frames, large bearings and wearing surfaces, and heavy wheels, assume with ease the shocks and strains to which engines are subject in this class of work.

To meet the various conditions of electric power purposes, we are prepared to furnish a variety of designs in horizontal and vertical, medium and high speed, allowing purchasers a wide choice in styles of designs.





SINGLE CYLINDER, CENTER CRANK RAILWAY ENGINE.

Page 10.

Factory and Mill Service.

Many factories are realizing the enormous loss of power due to the operation of long lines of shafting, and there has been a marked tendency to adopt the more modern and economical method of power transmission by electricity.

The most progressive manufacturers are now driving their machines direct by means of electric motors, and their use is invariably attended by marked economical results.

For isolated machines, or for heavy machines that may be in occasional use, electricity is particularly adapted as a source of power, for such a means of transmission consumes power only when the machine is in operation.

There is also less liability to interruption to manufacture, on account of the subdivision of power, and in case of running overtime it is not necessary to operate the whole works, with its usual heavy load of transmitting machinery, but such machines only as are required.

Another important advantage of electric transmission of power is the adaptability of the system to changes and extensions. New motors may be added without interfering with those already in operation, and the ease with which the system lends itself to varying the speed of the different units is a very potent factor in its favor.

The superiority of our high-speed, automatically controlled engine has been demonstrated so thoroughly in electric light and power stations, requiring and consuming large amounts of power, that there is no question of its economical adaptability for mill and factory service.

Our engine is recommended particularly for this class of duty, as its initial cost, set and connected, will generally be less than that of a high-grade, slow-speed engine, while the operative economy will be found wholly in our favor. In addition to this, the absolute regulation of the engine under sudden changes of load or steam pressure, is a safeguard against the disastrous consequences so often chronicled as attending such condition where the ordinary type of engine is employed.

GENERAL DESCRIPTION.

The Governor.

The production of thoroughly satisfactory incandescent lighting affords the severest test of steam engine governors, and it is under the stimulus of this service that they have reached their present high stage of development. No more trying situation for a governor could perhaps be imagined than that which often occurs in modern office buildings, where the engine which furnishes power for the lights also operates electric elevators. From the nature of the service, the load is continually changing. The slightest variation in speed for even a moment causes the lights to waver, and it is, therefore, necessary that not only should the speed be uniform, but it should continue so during the period of change. This has been practically impossible in governors of the past, owing to the many connections under severe strains causing friction, the deadly enemy of good regulation.

In our recently adopted governor, the centrifugal element, upon which the degree of refinement of all governors depends, is combined with an inertia element, relatively so great that instant and extreme changes of load are immediately provided for, without waiting for the otherwise necessary manifestations of centrifugal force. It not only regulates to a very high degree of perfection, but with a very rapid adjustment and without the slightest instability, and therefore admirably fulfills the demands. The entire governor consists of a single moving piece suspended upon one pivotal point, thereby reducing friction to a minimum. The suspension pin, which is of ample size, is made of hardened tool steel. The suspension pin eye is lined with non-frictionless metal, and the little lubrication that is required is accomplished by forcing grease, by means of a compression grease cup, into a number of recesses arranged around the bore of the bushing.

Its simplicity, as well as fine regulation, will, we believe, recommend this governor to users of engines.

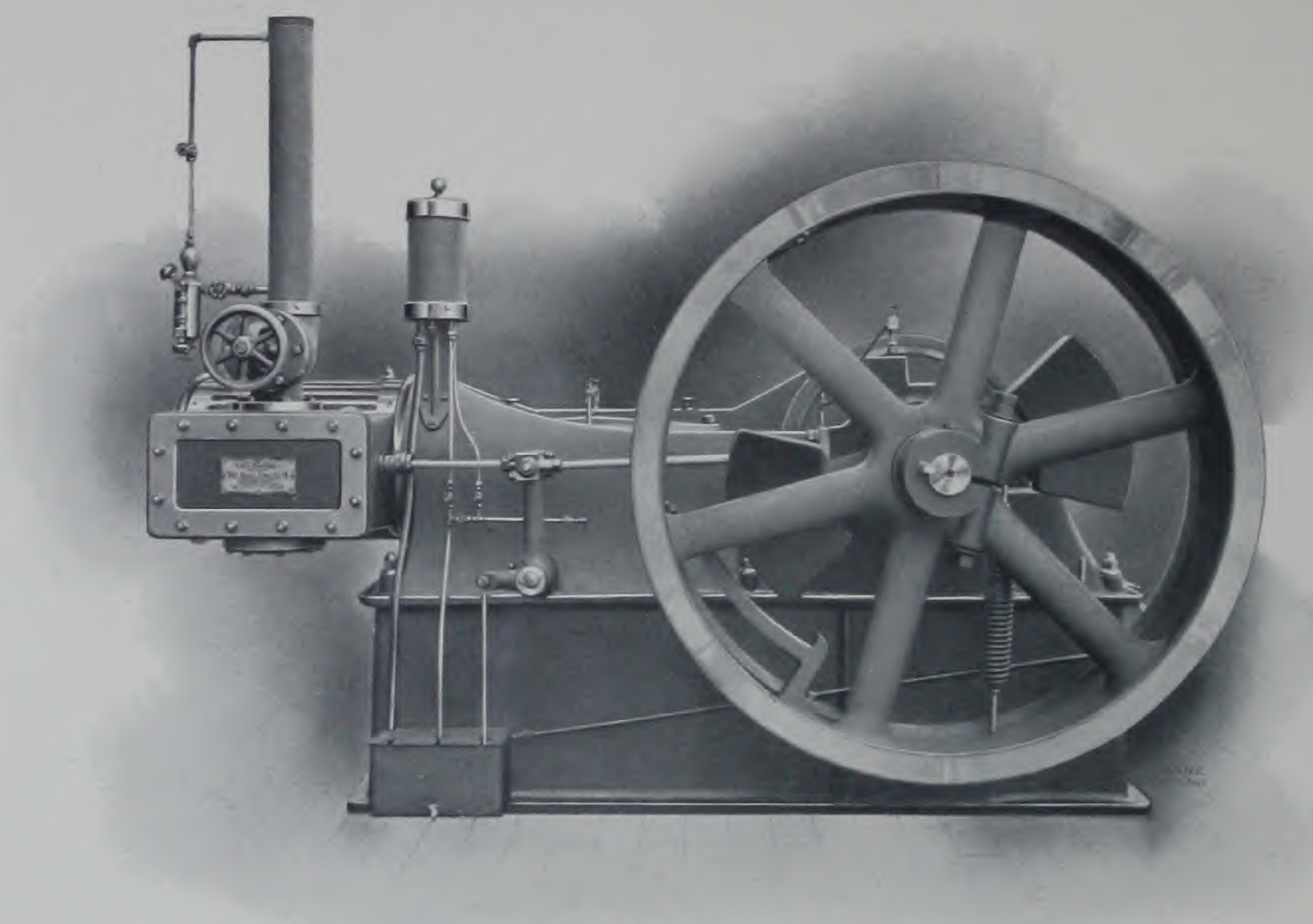
The Valve.

If several engines are designed with equal skill, are equally well made, use steam at the same pressure, expand to the same extent, labor under the same conditions, and the valves are all steam tight, the difference in economy due to the class of valve gear employed, will be small, and the differences found to exist may be traced less to mechanical than to thermal conditions, to questions of condensation in cylinders, radiation, etc. Good diagrams depend more upon proper proportions and proper valve setting than upon valve gear.

Our engines are of the single-valve type, which construction gives them the advantage of simplicity. This advantage is emphasized and made a feature of pronounced and absolute superiority, by the fact that the valve, by reason of its design and action, is perfectly steam tight and remains so throughout its entire life. This tightness is secured and maintained by a steam enforced contact, alike at all points of the stroke, of perfectly smooth surfaces, positively preventing live steam blowing into the exhaust during admission, or into the port during exhaust.

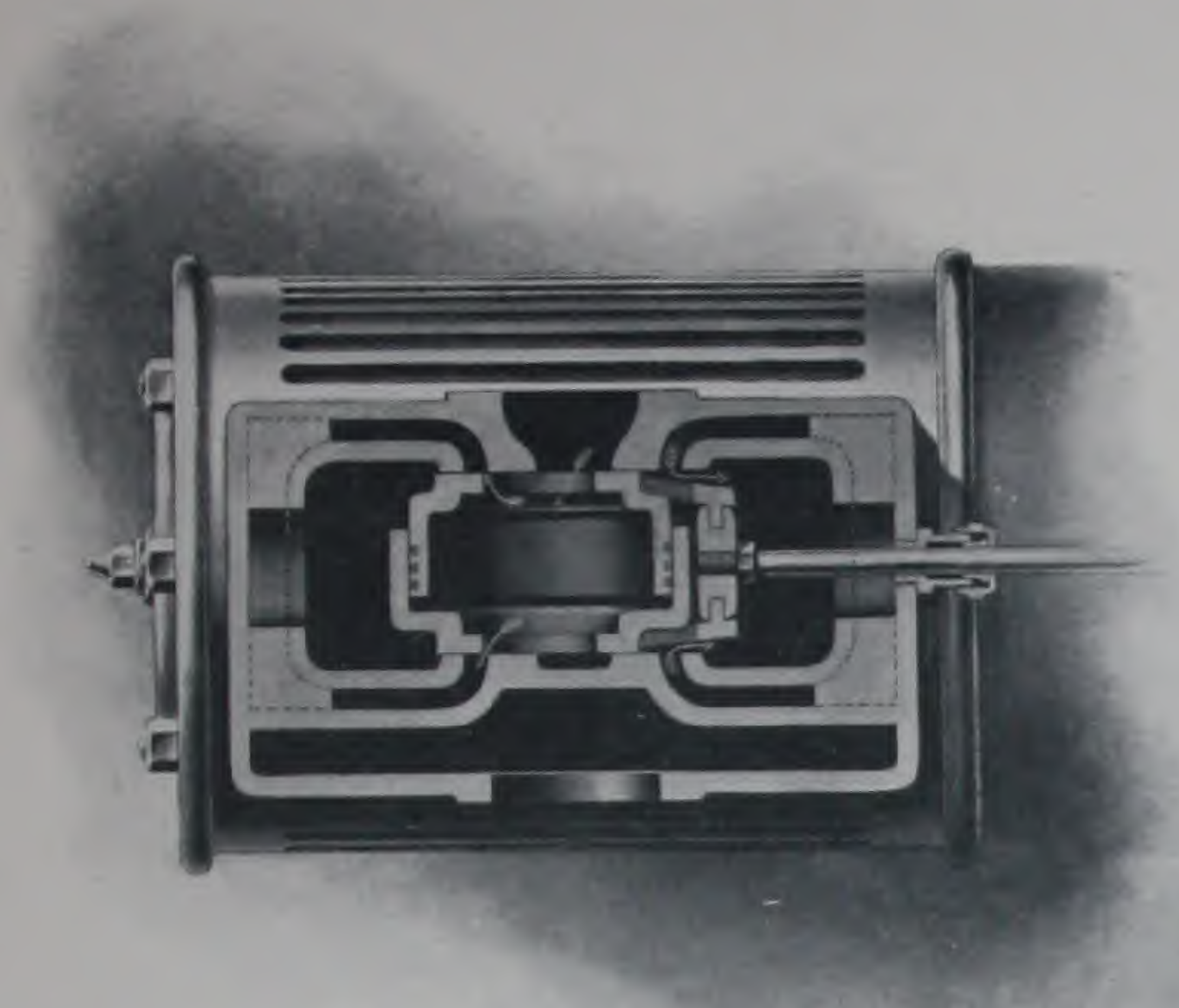
The construction of the valve is quite clearly shown by the detailed illustrations herewith. It consists of two parts, telescopically connected, this construction permitting each part to adjust itself to its seat. The valve is, in reality, a double-faced valve, with each face independently and automatically adjustable to its own seat.

When it is considered that many of the valves in use have no provision whatever for taking up wear, and in those that have such provision the adjustments are so delicate that the average engineer generally leaves the valve untouched, the great advantage of our form of valve becomes at once apparent.



SINGLE CYLINDER ENGINE

WITH AUTOMATIC LUBRICATION.



The Valve.

Referring to the illustrations, the manner of its adjustment to its seat will be made clear by the explanation that steam enters at the top, forcing, in its efforts to escape, the two parts of the valve apart until each rests squarely against the seat, and this forcing apart is continuous and constant from one end of the stroke to the other.

The vertical and horizontal sectional views of the cylinder make clear the manner of operating the valve, and the steam distribution to the cylinder.

The Cylinders.

The cylinders of our engines are cast from close-grained charcoal iron and are accurately bored to size. By reason of the material used the cylinder becomes highly polished and the wear in service is very slight. The cylinders are lagged with nickel-plated jackets with a layer of non-conducting material between. Both cylinder heads are made steam tight by ground joints.

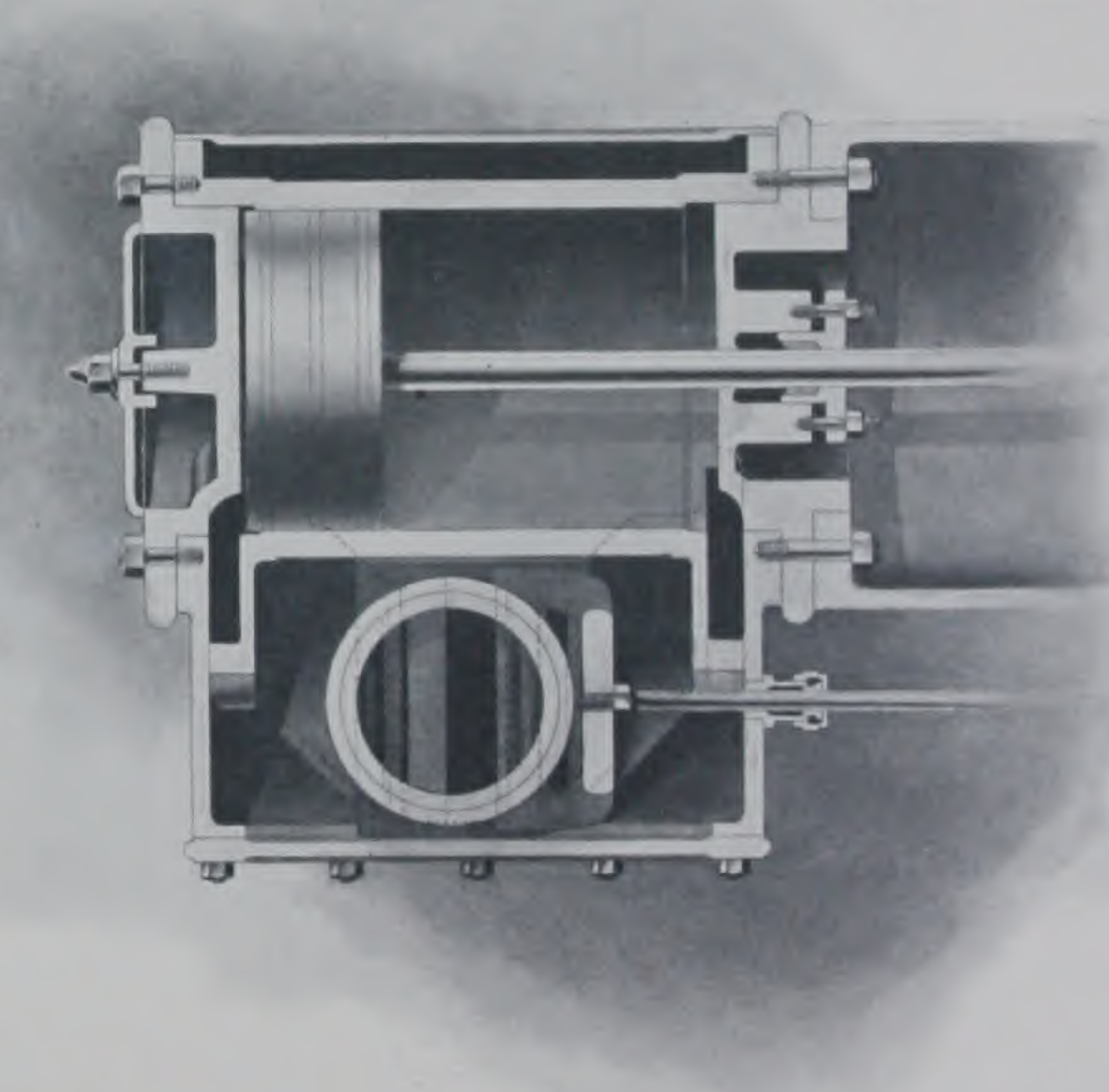
The pistons are as light as consistent with the proper strength.

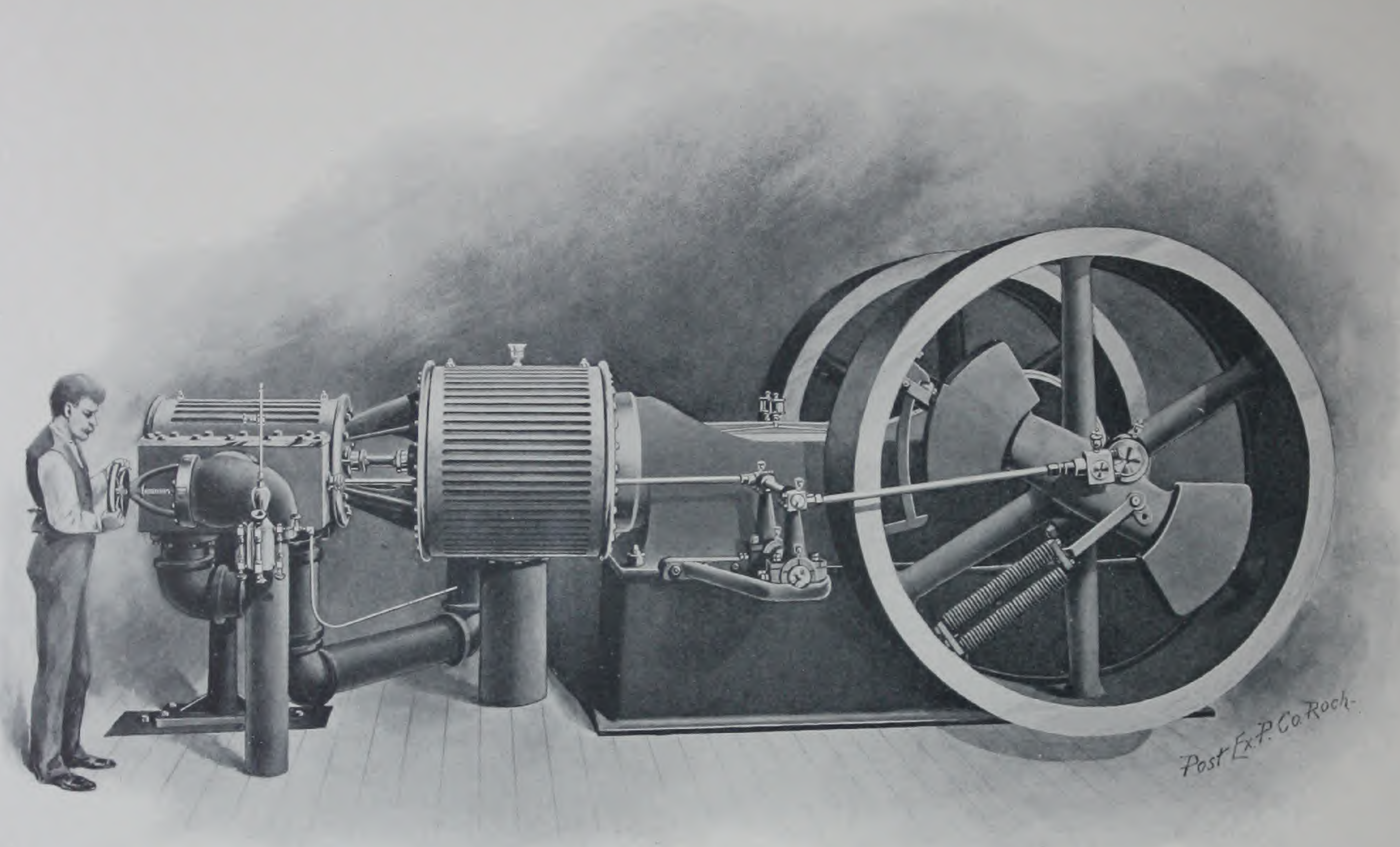
The piston rings are self-adjusting and give a steam-tight fit with little friction.

The piston rod is joined to the head in the most secure manner, and a fine quality of crucible steel is used in the rod to give the least possible wear and greatest amount of strength.

The wearing surfaces of the crosshead, which in our horizontal high-speed engines is of the locomotive type, are very large, faced with best babbitt metal, and are carefully scraped to perfect bearings.

The crosshead pin is tool steel, ground absolutely true.

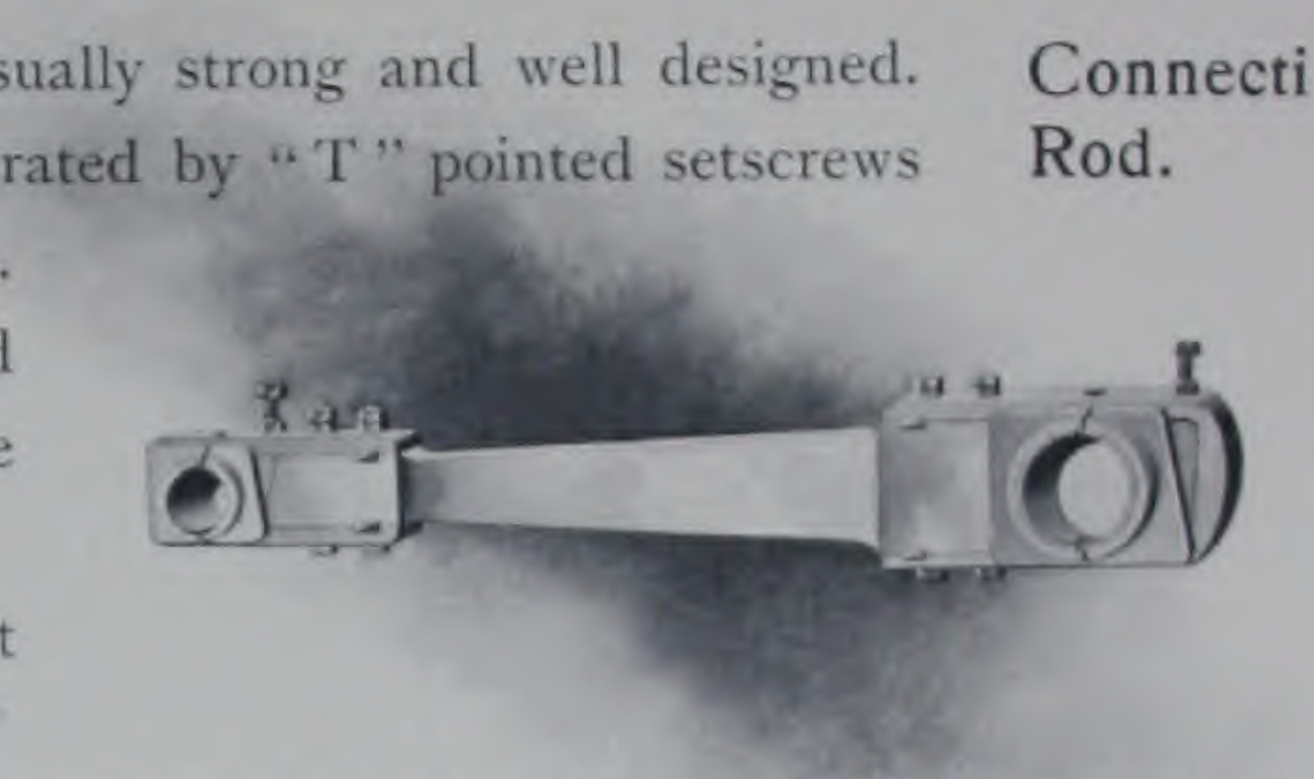




STANDARD TANDEM COMPOUND ENGINE.

Connecting Rod.

The connecting rod and straps are forged from steel blooms and are unusually strong and well designed. The adjustment of the boxes on both ends of the rod is by means of wedges operated by "T" pointed setscrews placed in the top of the rod, which move the wedges up or down for adjustment. As the movement of the wedges is in the same direction, the length of the rod is not altered, nor is the position of the piston changed. The adjustments are made by hand and with a great degree of accuracy.



The crank boxes are lined with a grade of babbitt especially adapted for that purpose. The crosshead boxes are made of the best quality of brass.

Crank Shaft.

The crank shaft is a single forging of open-hearth steel, containing the proper amount of carbon to give exceptional strength and durability, the whole shaft being forged solid and the crank pin slotted out. The journals and crank pin are large, and the shaft is ground to perfectly round, smooth-running surfaces.

Cast-iron discs containing the counterbalance are secured to the shaft in such a manner as to prevent any possibility of their getting loose, and in such a manner, also, as not to impair the strength of the shaft. The proportions of the counterbalance are such as to insure perfect balance.

Guides.

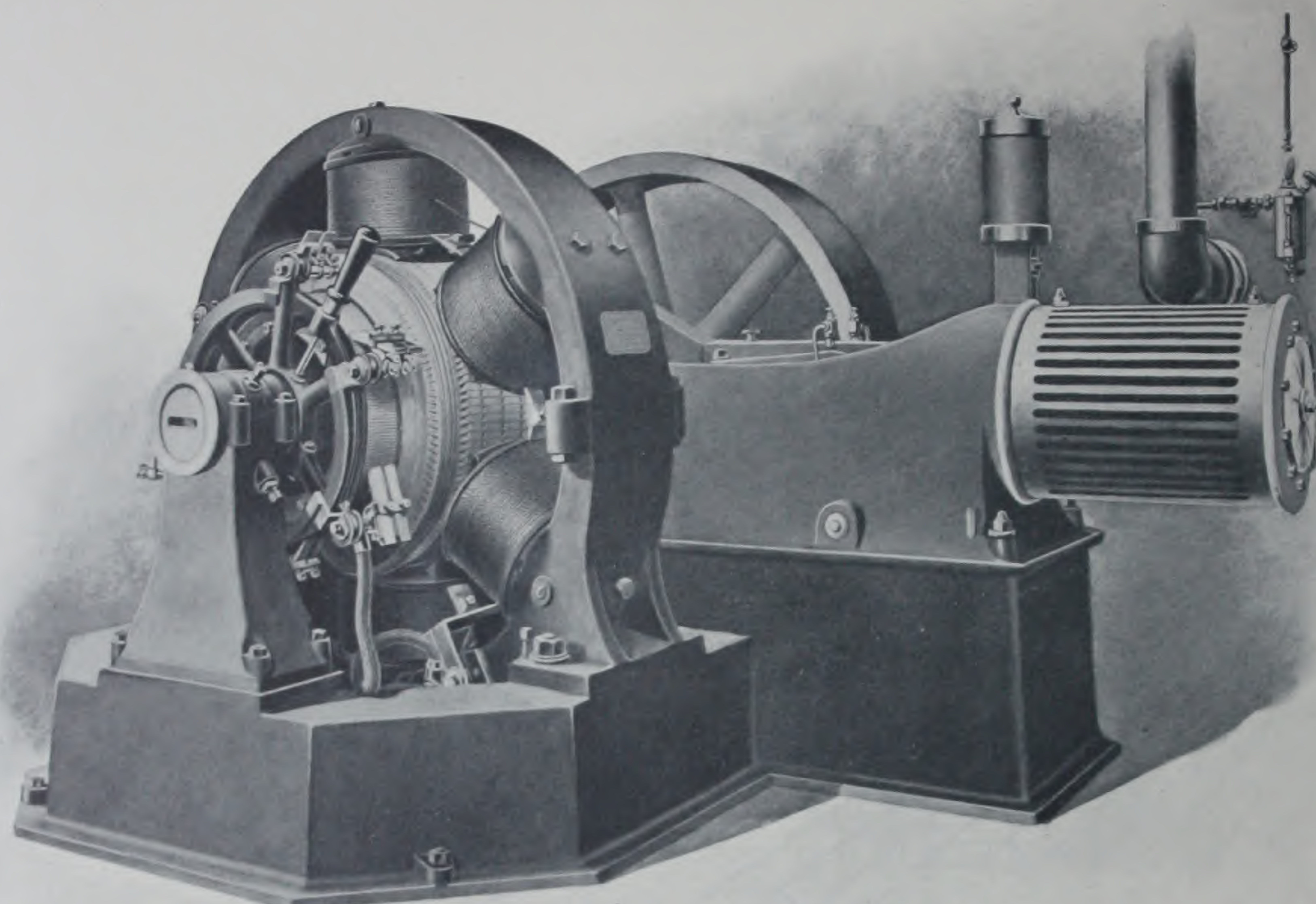
The construction of upper and lower guides allows for adjustment for wear. The lower guides are separate from the frame, and in case of accident can be replaced with new ones, which is impossible with designs having lower guides integral with the frame. The iron used in both upper and lower guides is made of hard material carefully scraped, and years of use show but slight wear.

Main Bearings.

The main bearings contain adjustable boxes by which the wear can be taken up, keeping the shaft in correct alignment and maintaining a perfect bearing. The boxes have removable babbitt shells, which can be quickly removed, should occasion arise.

Wheels.

The wheels are strong, well proportioned, with a large margin for safety, have flanges on both edges of rim, and are carefully balanced and well finished. The shaft-eye is, by special tool, reamed out to a perfect fit to the shaft. In the larger sizes of wheels the hub is split on one side. A large bolt connects the two parts, and when



SINGLE CYLINDER ENGINE.

DIRECT CONNECTED.

this is drawn up by the nuts, it produces the equivalent of a forced fit, rendering it impossible for the wheel to ever get loose.

Fittings.

All wrenches and other supplies are of the very best, and the outfit consists of everything necessary for the proper manipulation of the engine.

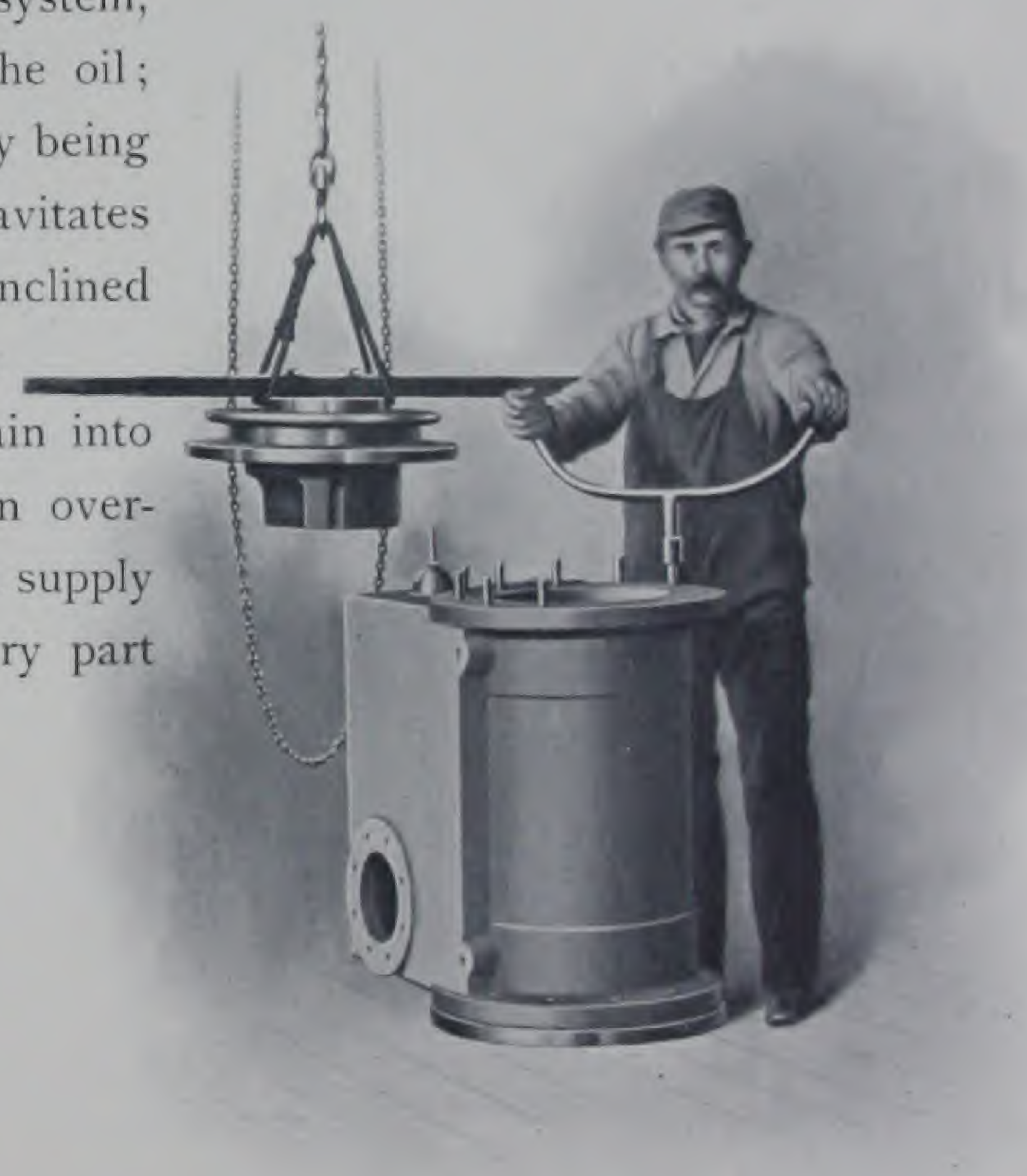
Oiling Devices.

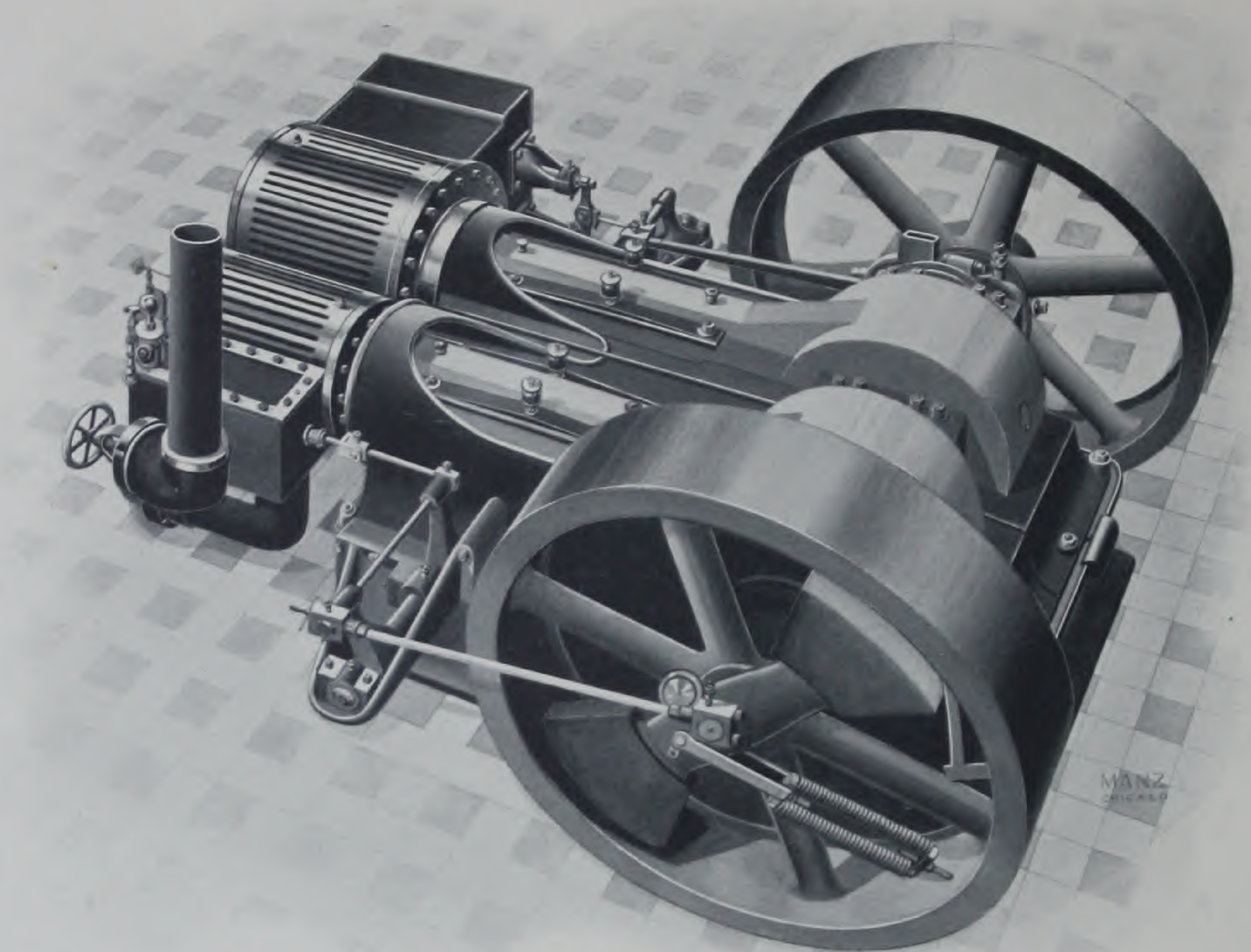
We are prepared to furnish either one of three forms of oiling devices with our engines:

First. Oiling by means of stationary sight-feed oil cups placed on the various points to be oiled, a method which is still preferred by many engineers.

Second. The gravity system of supply from a reservoir placed above the engine to graduated sight-feed oilers, located at the various oiling points on the engine, to which the oil is carried through a system of internal piping.

Third. The above system made automatic by means of a pump that is driven continuously from the valve motion, delivering oil into the reservoir. The pipes are so connected that direct pressure may be established on the supply pipe for the purpose of removing any obstruction, should any occur. This system of oiling has advantages over the splash or direct-forcing system, for in such systems, in the process of elevating oil to a sufficient height to feed over the engine, the oil becomes ærated; while in our system, by pumping into an upper reservoir, there is an opportunity for the air to leave the oil; consequently each of the feeds shows clear oil instead of being almost saponified by being filled with air. The oil, after having been distributed over the running surfaces, gravitates down to the bottom of the inside of the frame, and from there is led through an inclined pipe to the receiving-tank sitting near the floor level. Here the oil passes through screens, to remove any floating particles of foreign matter, and is then pumped again into the upper reservoir, while the surplus oil is carried back to the receiving-tank by an overflow pipe. This arrangement insures an absolute flood of oil if desired, as well as a supply of oil for a long time without the use of the pump. By this arrangement every part requiring lubrication is constantly and copiously lubricated with clear, clean oil.





CROSS COMPOUND ENGINE.

To insure perfect cleanliness, we provide with all of our engines light hoods covering crosshead and crank discs, completely closing in the engine and absolutely preventing oil from being thrown on surroundings, while at the same time allowing easy access to these parts. The arrangement for preventing the oil from creeping along the shaft is also very complete. This is very important to prevent injury to the dynamo in direct-connected engines.

Oiling Devices.

We do not provide sub-bases unless especially ordered, although we recommend their use, as they give a finished appearance to engines, and, when filled with concrete, add to the weight and solidity of the foundations.

Sub-base.

All horizontal engines are built right-handed, unless otherwise ordered. By a right-hand engine we mean one that has its governor-wheel on the right-hand side of the engine when looking from the cylinder-head end of the engine towards the wheels.

Hand of Engines.

The points of value to which we especially invite attention are simplicity and compactness, the solidity and strength of the bed, the large bearings and wearing surfaces, excellence of material and workmanship, economy, durability, good regulation, smooth and quiet running.

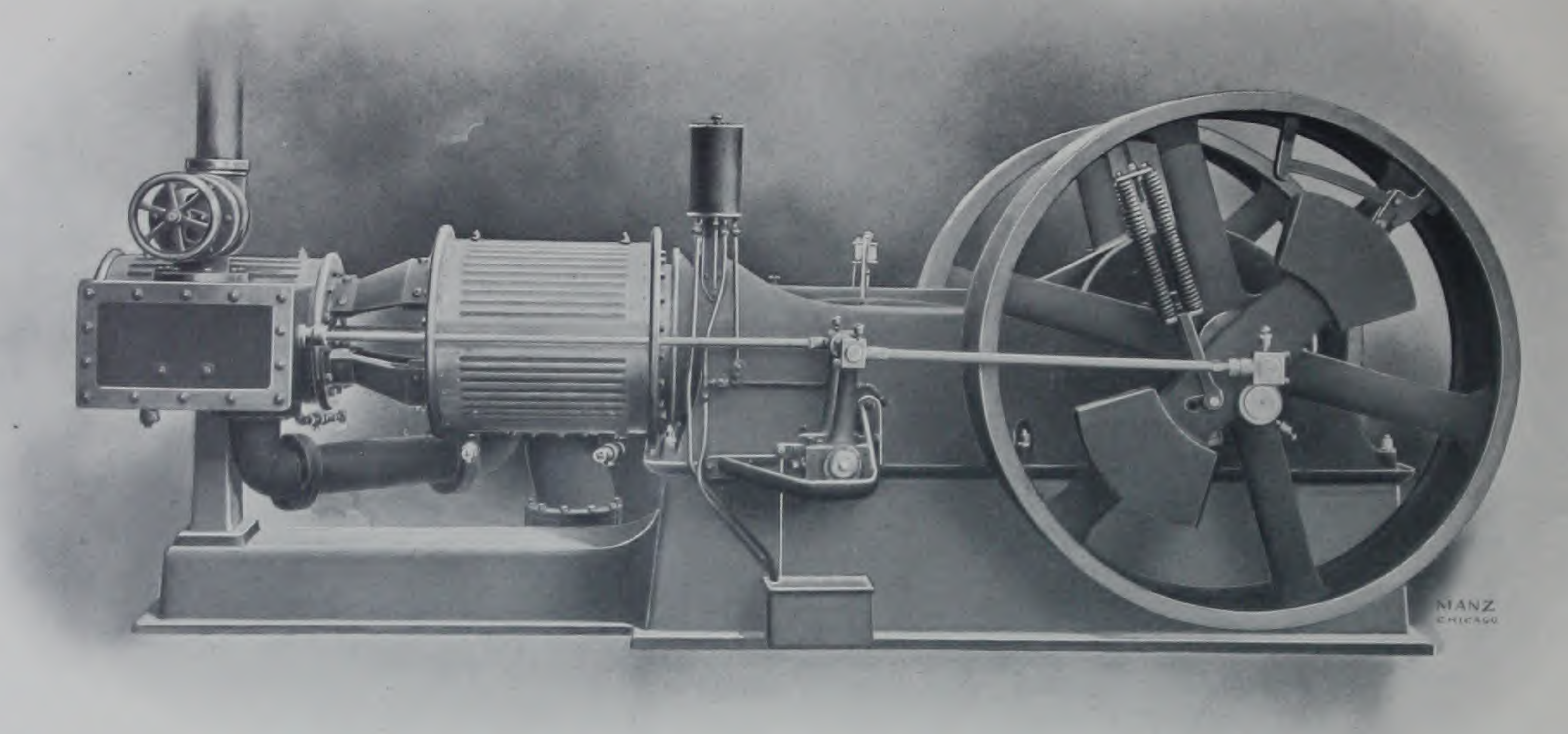
We spare no pains in the inspection of our work, using first-class material only, and confidently assert that these engines are unsurpassed.

Before shipping, each engine is placed on a foundation and thoroughly tested under all the conditions that will ever be required of it. Indicator cards are taken, and tests by means of a tachometer are made of the regulation under different conditions of load and boiler pressure.

Testing.

Appreciating the fact that when repairs are ordered they are wanted quickly, we keep in stock all the parts going to make up each size and type of engine, and are, therefore, enabled to ship promptly any repairs ordered. Our systems of records being perfect, and all parts made interchangeable, we can assure our customers that all repairs will be sent correctly and warranted to fit.

Repairs.

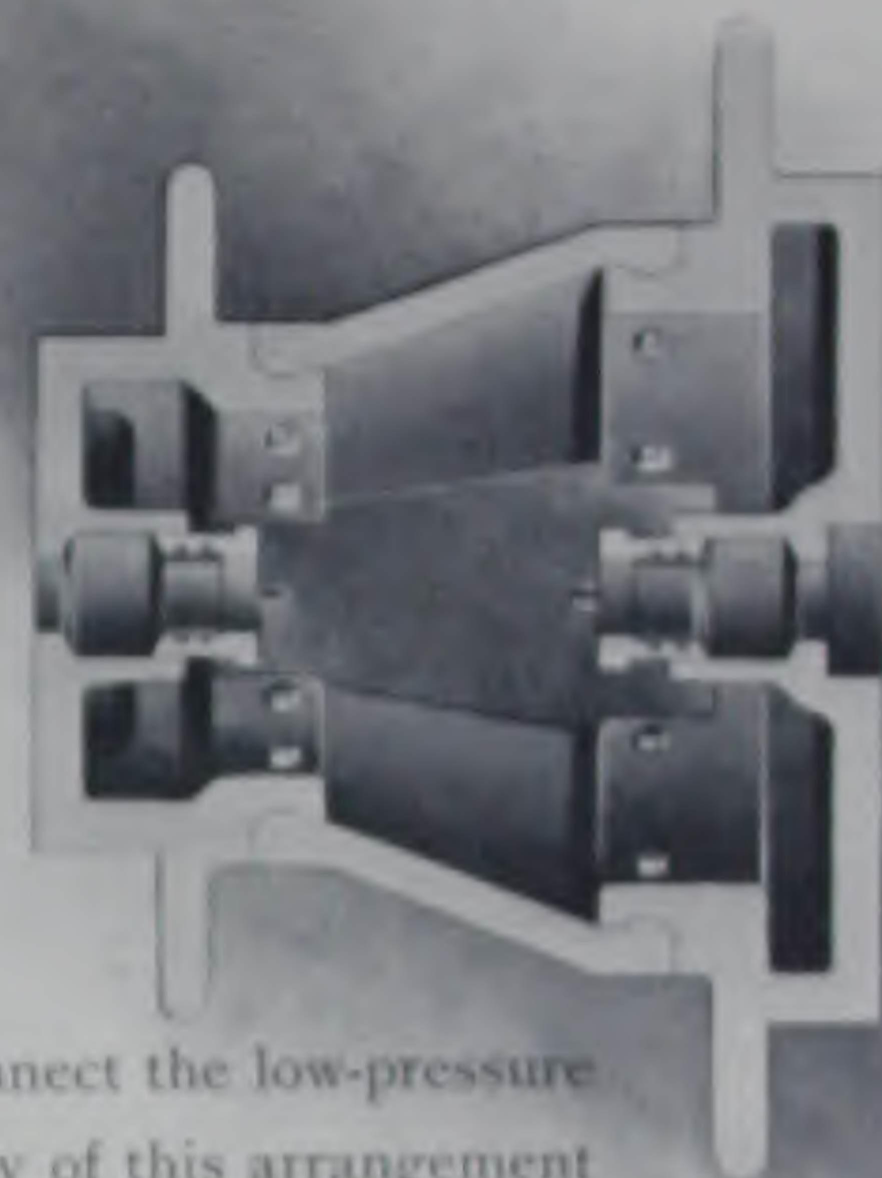


TANDEM COMPOUND ENGINE

WITH DIVIDED HEAD AND BASE EXTENDED UNDER CYLINDERS.

Page 22.

Tandem and Cross Compound Engines.



Tandem Compound.

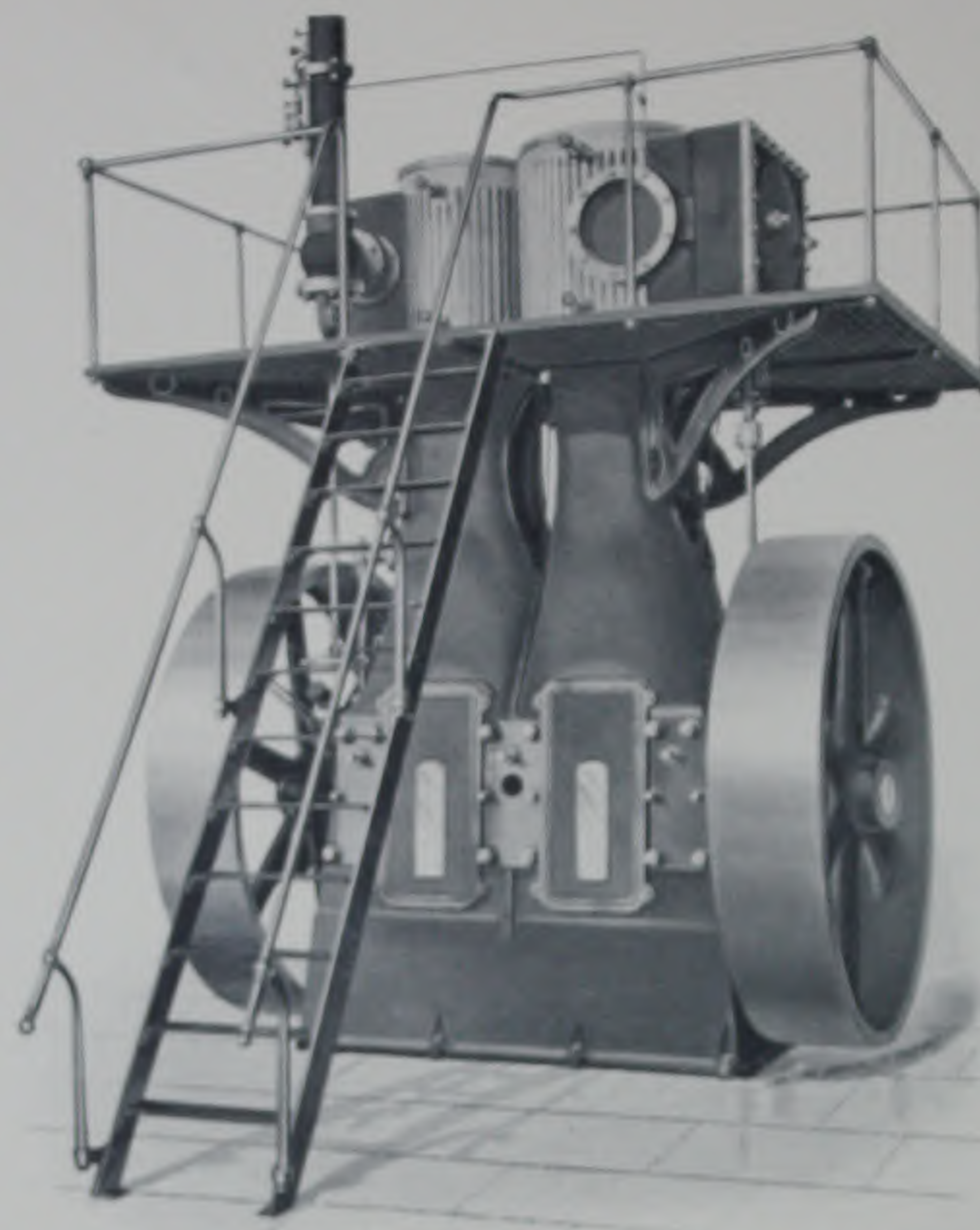
In our Tandem Compound Engine the general features of frame, shaft, valve, and governor which distinguish our Single Cylinder Engine are preserved, while the arrangement of the valve motions, one on each side of the engine, avoids the unsatisfactory results of complicated valve gear.

This type of engine is furnished with sub-base extended under cylinders and divided head, with plain base under frame only, or without base, as desired. The divided head between cylinders provides access to the low-pressure cylinder without the necessity of removing the high-pressure cylinder. The illustration shows that it consists of two half-conical shells, which, by tongued and grooved joints, connect the low-pressure cylinder with the high-pressure cylinder, and are held in place by bolts. The simplicity of this arrangement is apparent. The head may be entirely removed, allowing free access to either or both cylinders, and is easily and quickly replaced, with the certainty that it will fit accurately in position. A further advantage of this form of construction lies in the fact that the pulsating strain incident to power transmission is taken up by the grooved joints, and not by the bolts that hold the head in position.

Cross Compound.

The Cross Compound Engine occupies less floor space for equal power than a Tandem Compound Engine, and permits of a higher rotative speed and a freer access to the pistons. The speed of the engine adapts it for direct connection to line shafting, from which a number of dynamos are to be driven, thus avoiding the use of wide and expensive belts, and minimizing the space otherwise involved in getting a sufficient distance between the engine and line shafting to obtain proper belt transmission.

Nine years of successful experience in building compound engines justifies us in the assurance that for economy and reliability they are not excelled by any other.



VERTICAL CROSS COMPOUND ENGINE.

Vertical Engines.

We build Single Cylinder, Tandem Compound, and Cross Compound vertical engines, but as an example of our general construction, we illustrate and describe our Cross Compound vertical engine.

In the design of this engine it was desired that the main pieces should be absolutely rigid and indestructible, allow ease of access for adjustment or removal of any part subject to wear, and, while covering these points, to produce an engine whose steam distribution should be symmetrical on both sides of all the pistons, whether one, two, three, or four were used; in other words, an independent valve motion for each and every cylinder employed, and each of these to be a perfect engine in itself.

The main proposition as to strength and indestructibility is fully covered in the symmetrical form of the upright housings, which constitute one double housing by having one side of each planed and bolted together in the center of the middle shaft bearing. This substantiality is still further increased by planing the bottom of both housings to one continuous flat surface, to meet the planed surface of the top of the single base-plate to which the bottoms of the housings are bolted.

The introduction of the shaft is accomplished by arranging the shaft boxings in a large jaw cut into one side of the housing deep enough to bring the center of the shaft in a plane with the center of the housing.

These boxes consist of one lower, two quarter, and one top box for each journal, and are provided with removable babbitt metal shells upon which the journals bear. These shaft-box jaws are in turn closed by the use of heavy struts, fitted so that when bolted in the jaw is closed and completes the symmetrical strength of the four corners of each housing, each strut being fitted so that there can be neither contraction nor extension of the outer end of the jaw.

Each housing is also pierced by the large rectangular opening on each side (shown covered by a door bolted

on) as wide as the space between the inner edges of the struts and extending both high and low enough to allow the cranks with their counterbalancing discs to pass.

Hence, with shaft, boxes, and struts in place to close up the engine, it is only necessary to put up and secure large doors, which in turn are provided with a small shutter plate covering an opening large enough for the insertion of one's hand to feel the connecting-rod strap when engine is in motion, and the necessary wrenches to key up the crank boxes when so desired, while the adjustment of the journal boxes is accomplished by turning three set-screws, shown in each strut, the two in the center reaching the quarter boxes, while the third one above operates, either in or out, a wedge which fills between the upper side of the jaw in housing and the top box, thus giving independent adjustment for three parts of each box, while the lower box is perfectly free to move at right angles to the axis of the shaft, thereby giving, for all positions of adjustment of the quarter boxes, a full bearing for the shaft.

Above the openings for the shaft the housing becomes a round taper column, having on two sides of its inner surface the cross-head guide surfaces, which are cast in place and bored out coincident with the boring and facing of the upper end for the reception of the cylinders and the lower end for its seat upon the base. The other two sides of each housing are pierced by elliptical openings, making access easy to the crosshead and upper end of connecting rod.

In adopting this form of housing a structure is obtained that is strong, convenient of access when desired, clean as to any dirt leaving the engine, and entirely closed as to any dirt from the outside entering the engine, along with a natural ventilation past the shaft-boxes up the column and out of the elliptical openings therein.

The shaft is of one piece of forged steel from end to end, the crank-pins being 180 degrees apart and cut out of the solid down to their round diameter, and, as are the journals, ground to a perfectly round smooth-running surface.

The pins are provided with centrifugal oiling holes in addition to the regular supply, through the usual tube reaching from the upper to the lower end of connecting-rod.

Covering each pair of crank-bells is a pair of discs carrying a sufficient amount of counter-weight to give a perfect-running balance to the cranks and the reciprocating parts, so that there is practically no vibration to be communicated to the housings and hence to the upper works of the engine.

The connecting-rods are of forged steel, the upper end being solid and cut out for the reception of the brass crosshead box and the removable crosshead pin — the latter being very carefully tapered through the crosshead, and held in place by a fine threaded nut; the lower end being provided with an excellent design of strap, which, owing to the arrangement of the bolts and cross-keys, constitutes a solid end-rod for the crank as well as the upper end, and both ends are provided with the very best arrangement of wedge adjustment that can be conceived of, and which in operation does not alter the length of the rod.

The crossheads are of the double-plate pocket type, as used in many makes of Corliss engines; are provided with taper shoes to compensate for any wear that may occur against the guides, the shoes being of cast-iron with the running surface entirely covered with babbitt metal, the area of which is exceedingly liberal.

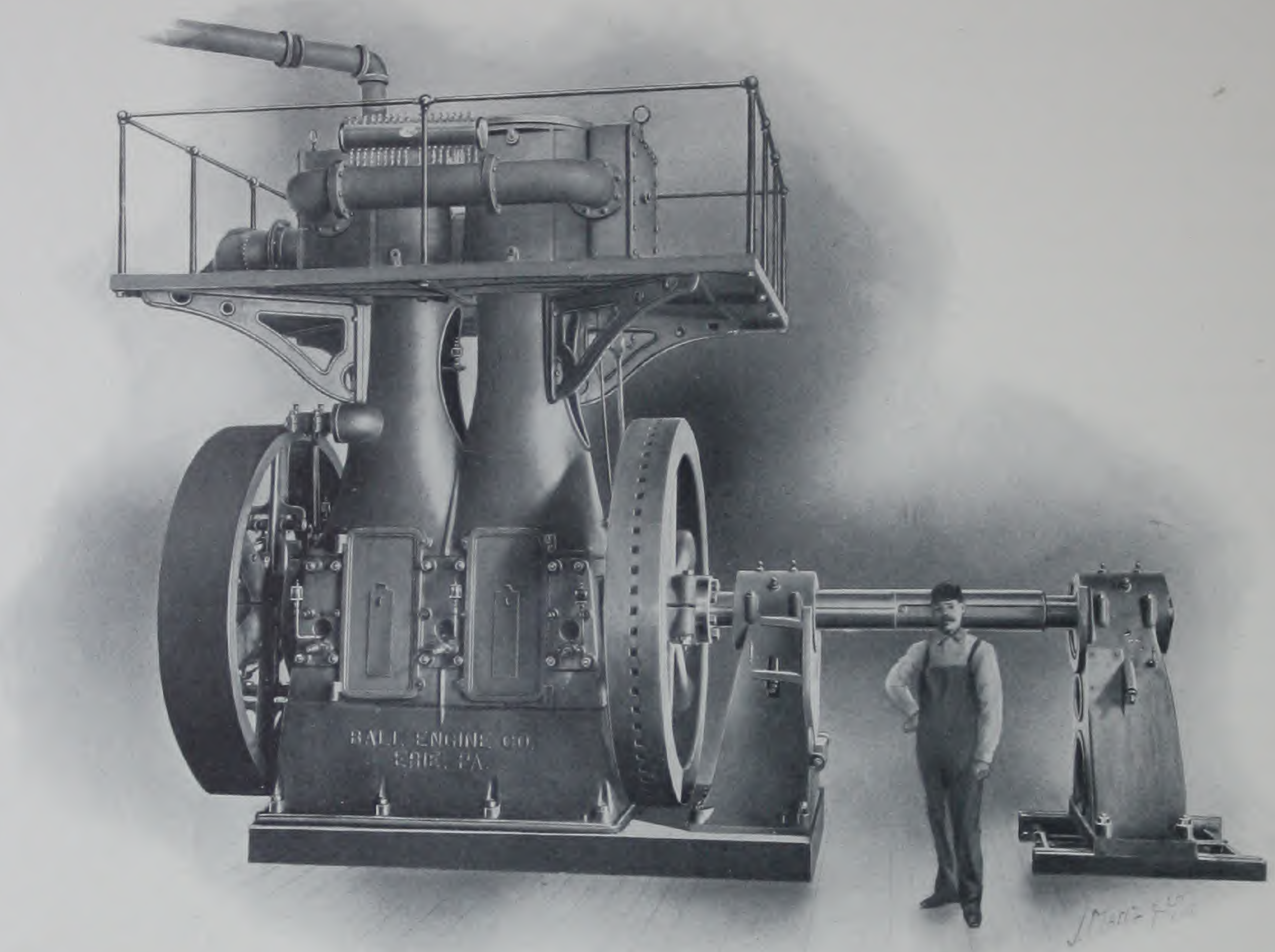
The piston-rods are of crucible steel, screwed into the crosshead.

The pistons are of the double-plate type, held up to a solid collar and taper by a well-fitted nut. The piston packing is made up of two self-adjusting parted rings and a broad junk ring for centering and guiding the piston in the cylinder.

The cylinders are of charcoal iron mixed in such proportion as to produce a very strong, close-grained iron, which enables the surfaces to take a mirror polish. They are provided with single valves, each of which is practically one piece so far as the motion and wear are concerned.

The high-pressure valve is of the double-faced, telescopic-relief type, with boiler pressure on the inside, a sufficient amount of unbalanced area being left on the faces that the force of the steam on the inside forces the two faces apart, causing each to rub against the seat with sufficient pressure to keep the surfaces polished and steam tight throughout the entire life of the engine.

The low-pressure valve is of the common letter D type, with improved proportion and construction; is provided



VERTICAL CROSS COMPOUND ENGINE.

ARRANGED FOR DIRECT CONNECTION.

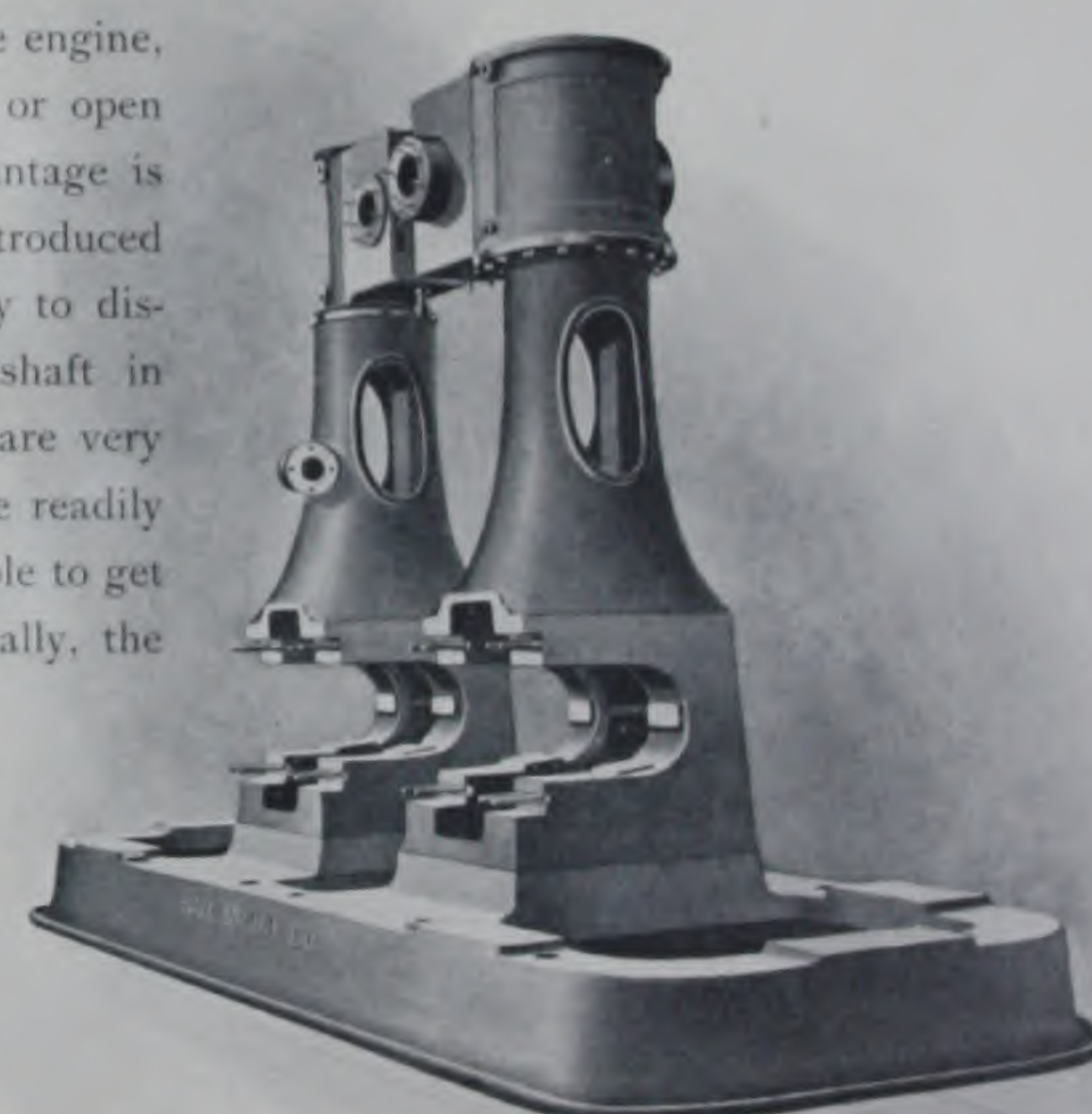
with a round relief area upon its back, operating against the chest cover, thus having a large, well-proportioned valve, that runs with the greatest ease and yet follows up its wear without attention from the outside.

The outward appearance of the engine is neat, symmetrical, and at once demonstrates that in this arrangement has been accomplished a great reduction of floor space required for this amount of power.

We provide with our vertical engines a complete system of stairways, stout and handsome platforms, and hand-railings.

The means of lubrication are very complete. From a central reservoir suspended from the upper part of the engine, the oil is led by gravity through brass tubes to the various bearings and wearing surfaces, the flow of oil from the central reservoir being controlled by means of adjustable sight-feeds connected with the reservoir, a separate feed being provided for each point to be lubricated.

In summing up the description of our vertical engines we would mention some of their principal claims for superior construction: The design of the housings is such that there is entire absence of the vibration to which many vertical engines are liable. The engine, being so thoroughly closed in, is much cleaner than those with A frames or open fronts, and the oil is not thrown on all the surroundings, and yet this advantage is combined with accessibility. Owing to the manner in which the shaft is introduced into the housings, as will be seen from the illustrations, it is not necessary to disconnect any columns or prop up any upper works either to place the shaft in position or roll it out of place. The means of keeping the shaft in line are very perfect, all of the adjustments being in front of the engine, where they are readily gotten at. The valve connections are simple and direct, and not as liable to get out of order or wear out as more complicated or less direct systems. Finally, the engines are economical in the use of steam, the regulation is of the best, the finish and workmanship are thorough, and we have no hesitation in offering them to our customers as being unexcelled in all principal points.



TABLES

SHOWING DIMENSIONS, POWERS, AND STANDARD SPEEDS
UNDER DIFFERENT PRESSURES OF

HORIZONTAL SINGLE CYLINDER ENGINES
HORIZONTAL TANDEM-COMPOUND ENGINES
HORIZONTAL CROSS-COMPOUND ENGINES
VERTICAL SINGLE CYLINDER ENGINES
VERTICAL COMPOUND ENGINES

STANDARD HORIZONTAL SINGLE-CYLINDER ENGINES.

Horse-power.			Cylinders.		Revolutions per Minutes.	Standard Wheel.	Width of Belt, Inches.	Floor Space.		Diam. of Pipes.	
80 Pounds.	90 Pounds.	100 Pounds.	Diameter, Inches.	Stroke, Inches.		Diameter Inches.		Length, Ft. In.	Width, Ft. In.	Steam, Inches.	Exhaust Inches.
20	23	25	6	8	450	30	8	6—6	3—6	2½	3
20	23	25	6	10	350	36	8	7—8	4—5	2½	3
28	31	35	7	8	450	30	8	6—6	3—6	2½	3½
27	30	34	7	10	350	36	8	7—8	4—5	2½	3½
36	41	46	8	8	450	32	8	6—6	3—6	2½	4
35	40	45	8	10	350	42	8	7—8	4—5	2½	4
40	45	50	8½	10	350	42	8	7—9	4—5	2½	4
50	56	62	9½	10	350	42	10	7—9	4—5	3	4½
46	51	58	9	12	300	48	10	9—3	5—6	3	4½
56	62	69	10	10	350	48	10	7—9	4—5	3½	5
56	63	70	10	12	300	48	10	9—3	5—6	3½	5
70	78	86	11	12	300	54	10	9—3	5—6	3½	5
82	92	103	12	12	300	54	10	9—6	5—6	4	6
97	109	121	13	12	300	60	12	10—3	5—9	4½	6
112	126	140	14	12	300	60	12	10—3	5—9	4½	7
120	135	150	14½	12	300	60	12	10—3	5—9	4½	7
115	130	145	14	14	265	66	12	10—6	5—9	4½	7
132	149	165	15	14	265	66	14	11—8	6—2	5	7
151	169	187	16	14	265	66	14	11—8	6—2	6	8
137	154	171	15	16	240	72	14	12—9	6—9	5	7
156	175	195	16	16	240	72	14	12—9	6—9	6	8
176	198	220	17	16	240	72	14	12—9	6—9	6	8
197	222	247	18	16	240	72	16	13—2	7—0	6	9
203	229	255	18	18	220	72	16	13—6	7—3	6	9
227	255	284	19	18	220	84	18	16—0	9—0	7	10
251	283	314	20	18	220	84	18	16—0	9—0	7	10
304	342	380	22	18	220	84	18	16—0	9—0	7	10

INDICATED HORSE POWER OF

SINGLE CYLINDER ENGINES AT DIFFERENT SPEEDS AND PRESSURES.

Cutting off Steam ¼ Stroke.

Size of Engine.	Revolutions per Minute.	Initial Steam Pressure. 80	90	100	Size of Engine.	Revolutions per Minute.	Initial Steam Pressure. 80	90	100
6 x 8	350	16.00	18.00	20.00	14 x 14	245	106.75	120.00	133.50
	400	18.15	20.60	22.90		265	115.50	130.00	144.50
	450	20.50	23.20	25.75		275	120.00	135.00	150.00
6 x 10	300	17.13	19.27	21.41	15 x 14	245	122.44	137.75	153.06
	330	18.84	21.20	23.55		265	132.44	149.00	165.55
	350	19.98	22.48	24.98		275	137.50	155.00	171.50
7 x 8	350	21.90	24.50	27.20	16 x 14	245	139.50	156.30	174.20
	400	24.90	28.05	31.05		265	151.00	169.50	187.50
	450	28.00	31.50	35.00		275	156.00	176.50	195.00
7 x 10	300	23.32	26.23	29.15	15 x 16	200	114.24	128.52	142.80
	330	25.64	28.86	32.07		230	131.16	147.55	163.95
	350	27.20	30.61	34.01		240	137.08	154.21	171.35
8 x 8	350	28.40	32.00	35.50	16 x 16	200	130.00	146.25	165.50
	400	32.50	36.56	40.60		330	148.24	166.77	185.30
	450	36.50	41.10	45.70		240	155.96	175.45	194.95
8 x 10	300	30.46	34.27	38.08	17 x 16	200	136.75	165.50	183.25
	330	33.50	37.69	41.88		230	167.50	188.00	209.00
	350	35.53	39.98	44.42		240	176.00	198.00	220.00
8½ x 10	300	34.30	38.75	43.00	18 x 16	200	164.46	185.01	205.57
	330	37.75	41.50	47.20		230	189.13	212.77	236.41
	350	40.10	45.00	50.10		240	197.35	222.02	246.69
9½ x 10	300	42.95	48.32	53.69	18 x 18	200	185.00	208.00	231.50
	330	47.25	53.16	59.06		210	194.25	219.00	243.00
	350	50.13	56.38	62.64		220	203.50	229.00	254.50
9 x 12	250	38.52	43.34	48.19	19 x 18	200	206.18	231.95	257.72
	280	43.15	48.20	53.97		210	216.51	243.57	270.64
	300	46.24	51.44	57.83		220	226.82	255.17	283.53
10 x 10	300	47.70	53.50	59.60	20 x 18	200	228.43	256.99	285.54
	330	52.40	59.00	65.50		210	239.90	269.89	299.88
	350	55.60	62.60	69.50		220	251.30	282.74	314.16
10 x 12	250	47.60	53.55	59.50	22 x 18	200	267.00	311.00	345.50
	280	53.31	59.98	66.64		210	290.00	327.00	362.50
	300	57.12	64.26	71.40		220	304.50	342.50	380.00
11 x 12	250	57.59	64.79	71.99	22 x 24	145	267.00	300.00	334.00
	280	64.50	72.56	80.63		155	285.75	321.50	357.00
	300	69.11	77.75	86.39		165	304.00	342.50	380.00
12 x 12	250	68.52	77.08	85.65	23 x 24	145	293.75	330.00	367.50
	280	76.75	86.34	95.94		155	314.00	353.50	393.00
	300	82.24	92.52	102.80		165	334.50	376.50	419.00
13 x 12	250	80.44	90.50	100.55	24 x 24	145	318.00	357.50	397.50
	280	90.09	101.36	112.62		155	340.00	382.50	425.00
	300	96.53	108.60	120.66		165	361.75	407.00	452.00
14 x 12	250	93.29	104.95	116.61	25 x 24	145	344.00	387.00	430.00
	280	104.48	117.54	130.60		155	367.50	413.50	459.00
	300	111.94	125.94	139.93		165	391.00	440.00	489.00
14½ x 12	250	100.00	112.50	125.00					
	280	116.50	126.00	140.00					
	300	120.00	135.00	150.00					

STANDARD HORIZONTAL TANDEM COMPOUND ENGINES, Non-Condensing.

Horse-power at 100 lbs. Non-Condensing.	Cylinders.			Revolutions per Minute.	Standard Wheel.	Width of Belt, Inches.	Floor Space.		Diam. of Pipes.	
	Diameters.		Stroke, Inches.							
	High P. Inches.	Low P. Inches.			Diameter, Inches.		Length, Ft. In.	Width, Ft. In.	Steam, Inches.	Exhaust, Inches.
65	8	13	12	300	48	12	12—0	5—6	3	6
90	9	16	12	300	54	12	13—0	6—0	3	8
115	10	18	12	300	60	12	13—6	6—3	4	9
140	11	19	14	265	66	14	15—0	6—8	4½	9
155	12	20	14	265	66	14	15—0	6—9	5	10
160	12	20	16	240	72	14	15—6	7—0	5	10
200	13	22	16	240	72	16	16—9	7—3	6	10
260	15	25	16	240	80	16	16—9	7—6	6	12
335	16	28	18	220	84	18	19—0	9—0	6	14
385	18	30	18	220	84	18	19—6	9—6	6	14

STANDARD HORIZONTAL TANDEM COMPOUND ENGINES, Condensing.

Horse-power at 100 lbs. Condensing.	Cylinders.			Revolutions per Minute.	Standard Wheel.	Width of Belt, Inches.	Floor Space.		Diam. of Pipes.	
	Diameters.		Stroke, Inches.							
	High P. Inches.	Low P. Inches.			Diameter, Inches.		Length, Ft. In.	Width, Ft. In.	Steam, Inches.	Exhaust, Inches.
75	8	13	12	300	48	12	12—0	5—6	3	6
105	9	16	12	300	54	12	13—0	6—0	3	8
130	10	18	12	300	60	12	13—6	6—3	4	9
160	11	19	14	265	66	14	15—0	6—8	4½	9
175	12	20	14	265	66	14	15—0	6—9	5	10
183	12	20	16	240	72	14	15—6	7—0	5	10
230	13	22	16	240	72	16	16—9	7—3	6	10
300	15	25	16	240	80	16	16—9	7—6	6	12
385	16	28	18	220	84	18	19—0	9—0	6	14
430	18	30	18	220	84	18	19—6	9—0	6	14

STANDARD HORIZONTAL CROSS COMPOUND ENGINES, Non-condensing.

Horse-power at 100 lbs. Non-condensing.	Cylinders.			Revolutions per Minute.	Standard Wheel.	Width of Belt, Inches.	Floor Space.		Diam. of Pipes.	
	Diameters.		Stroke, Inches.		Diameter, Inches.		Length, Ft. In.	Width, Ft. In.	Steam, Inches.	Exhaust, Inches.
	High P. Inches.	Low P. Inches.								
115	10	18	12	300	60	12	10—4	7—6	4	9
135	11	19	12	300	60	12	10—9	7—8	4½	9
150	12	20	12	300	66	12	11—0	7—9	4½	10
190	13	22	12	300	66	12	11—6	8—0	5	10
250	15	25	14	265	72	14	13—0	8—9	6	12
325	16	28	16	240	80	16	14—3	9—6	6	14
375	18	30	16	240	84	18	14—6	10—0	6	14
500	19	34	18	220	88	20	16—0	12—0	7	16
560	20	36	18	220	92	20	16—0	12—0	7	18

STANDARD HORIZONTAL CROSS COMPOUND ENGINES, Condensing.

Horse-power at 100 lbs. Condensing.	Cylinders.			Revolutions per Minute.	Standard Wheel.	Width of Belt, Inches.	Floor Space.		Diam. of Pipes.	
	Diameters.		Stroke, Inches.		Diameter, Inches.		Length, Ft. In.	Width, Ft. In.	Steam, Inches.	Exhaust, Inches.
	High P. Inches.	Low P. Inches.								
130	10	18	12	300	60	12	10—4	7—6	4	9
155	11	19	12	300	60	12	10—9	7—8	4½	9
170	12	20	12	300	66	12	11—0	7—9	4½	10
215	13	22	12	300	66	12	11—6	8—0	5	10
285	15	25	14	265	72	14	13—0	8-9	6	12
375	16	28	16	240	80	16	14—3	9—6	6	14
430	18	30	16	240	84	18	14—6	10—0	6	14
575	19	34	18	220	88	20	16—0	12—0	7	16
640	20	36	18	220	92	20	16—0	12—0	7	18

COMPOUND ENGINE RATINGS UNDER VARIOUS CONDITIONS.

HORSE POWERS.

Size of Engine.	Revolutions Per Minute.	Non-Condensing Steam Pressure.			Condensing Steam Pressure.		
		100 lb.	110 lb.	125 lb.	100 lb.	110 lb.	125 lb.
8 & 13 x 12	250	55	58	63	63	64	67
	275	60	63	69	69	70	73
	300	65	69	75	75	77	80
9 & 16 x 12	250	75	79	87	87	88	93
	275	82	87	96	96	98	105
	300	90	95	105	105	108	115
10 & 18 x 12	250	96	101	108	108	111	116
	275	105	111	119	119	123	128
	300	115	121	130	130	134	140
11 & 19 x 12	250	112	118	129	129	131	137
	275	124	131	142	142	145	151
	300	135	142	155	155	158	165
11 & 19 x 14	240	127	134	145	145	149	154
	250	132	139	151	151	155	160
	265	140	148	160	160	164	170
12 & 20 x 12	250	125	132	142	142	147	154
	275	137	145	156	156	161	169
	300	150	158	170	170	176	185
12 & 20 x 14	240	140	148	158	158	164	172
	250	146	154	165	165	171	180
	265	155	164	175	175	182	190
12 & 20 x 16	200	133	140	151	151	156	162
	220	147	155	168	168	172	179
	240	160	169	183	183	189	195
13 & 22 x 12	250	159	168	179	179	186	192
	275	175	185	197	197	205	210
	300	190	200	215	215	223	230
13 & 22 x 16	200	167	176	192	192	196	205
	220	183	193	210	210	215	225
	240	200	211	230	230	234	245
15 & 25 x 14	240	225	237	258	258	264	275
	250	235	248	270	270	275	288
	265	250	264	285	285	293	305

Size of Engine.	Revolutions Per Minute.	Non-Condensing Steam Pressure.			Condensing Steam Pressure.		
		100 lb.	110 lb.	125 lb.	100 lb.	110 lb.	125 lb.
15 & 25 x 16	200	218	230	250	250	255	265
	220	240	253	275	275	281	290
	240	260	275	300	300	305	315
16 & 28 x 16	200	270	285	312	312	316	330
	220	298	315	345	345	349	360
	240	325	343	375	375	381	395
16 & 28 x 18	200	305	322	350	350	357	375
	210	320	338	365	365	375	390
	220	335	353	385	385	393	410
16 & 28 x 24	145	294	310	338	338	345	360
	155	315	332	362	362	369	385
	165	335	353	385	385	393	410
16 & 28 x 22	180	335	353	385	385	393	410
18 & 30 x 16	200	312	330	360	360	366	380
	220	343	362	395	395	402	418
	240	375	395	430	430	440	455
18 & 30 x 18	200	350	370	400	400	410	430
	210	370	390	420	420	434	450
	220	385	405	440	440	450	470
18 & 30 x 24	145	338	356	387	387	395	413
	155	362	380	413	413	422	441
	165	385	405	440	440	450	470
18 & 30 x 22	180	385	405	440	440	450	470
19 & 34 x 18	200	455	480	525	525	533	555
	210	475	500	550	550	556	580
	220	500	528	575	575	586	610
20 & 36 x 18	200	510	538	585	585	598	620
	210	535	565	610	610	627	650
	220	560	590	640	640	657	680

HORIZONTAL SINGLE-CYLINDER ELECTRIC RAILWAY ENGINES.

Horse-power.			Cylinders.		Revolutions per Minute.	Standard Wheel.	Width of Belt, Inches.	Floor Space.		Diam. of Pipes.	
80 Pounds.	90 Pounds.	100 Pounds.	Diameter, Inches.	Stroke, Inches.		Diameter, Inches.		Length, Ft. In.	Width, Ft. In.	Steam, Inches.	Exhaust, Inches.
97	109	121	13	12	300	60	12	10—3	5—9	4½	6
132	149	165	15	14	265	66	14	11—8	6—2	5	7
137	154	171	15	16	240	72	14	12—9	6—9	5	7
156	175	195	16	16	240	72	14	12—9	6—9	6	8
176	198	220	17	16	240	72	14	12—9	6—9	6	8
197	222	247	18	16	240	72	16	13—2	7—0	6	9
227	255	284	19	18	220	84	18	16—0	9—0	7	10
251	283	314	20	18	220	84	18	16—0	9—0	7	10
304	342	380	22	18	220	84	18	16—0	9—0	7	10

HORIZONTAL TANDEM COMPOUND ELECTRIC RAILWAY ENGINES.

Horse-power at 100 lbs. Non-condensing.	Cylinders.			Revolutions per Minute.	Standard Wheel.	Width of Belt, Inches.	Floor Space.		Diam. of Pipes.	
	Diameters.		Stroke, Inches.		Diameter, Inches.		Length, Ft. In.	Width, Ft. In.	Steam, Inches.	Exhaust, Inches.
	High P. Inches.	Low P. Inches.								
115	10	18	12	300	60	12	13—6	6—3	4	9
140	11	19	14	265	66	14	13—0	6—8	4½	9
160	12	20	16	240	72	14	15—6	7—0	5	10
200	13	22	16	240	72	16	16—9	7—3	6	10
260	15	25	16	240	80	16	16—9	7—6	6	12
335	16	28	18	220	84	18	19—0	9—0	6	14
385	18	30	18	220	84	18	19—6	9—0	6	14

HORIZONTAL CROSS COMPOUND ELECTRIC RAILWAY ENGINES.

Horse-power at 100 lbs. Non-condensing.	Cylinders.			Revolutions per Minute.	Standard Wheel.	Width of Belt, Inches.	Floor Space.		Diam. of Pipes.	
	Diameters.		Stroke, Inches.		Diameter, Inches.		Length, Ft. In.	Width, Ft. In.	Steam, Inches.	Exhaust, Inches.
	High P. Inches.	Low P. Inches.								
200	13	22	16	240	70	16	14—3	9—6	6	10
260	15	25	16	240	72	16	14—3	9—6	6	12
325	16	28	16	240	80	16	14—3	9—6	6	14
375	18	30	16	240	84	18	14—6	10—0	6	14
500	19	34	18	220	88	20	16—0	12—0	7	16
560	20	36	18	220	92	20	16—0	12—0	7	18

MEDIUM SPEED, HORIZONTAL SIDE CRANK SINGLE CYLINDER ENGINES.

Horse-power.			Cylinders.		Revolutions per Minute.	Standard Wheel.	Width of Belt, Inches.	Floor Space.		Diam. of Pipes.	
80 Pounds.	90 Pounds.	100 Pounds.	Diameter, Inches.	Stroke, Inches.		Diameter, Inches.		Length, Ft. In.	Width, Ft. In.	Steam, Inches.	Exhaust, Inches.
300	340	380	22	24	165	120	22	19—0	12—0	7	10
330	370	410	23	24	165	120	22	19—0	12—0	8	10
360	400	445	24	24	165	120	26	19—0	13—0	8	12
390	440	490	25	24	165	120	26	19—0	13—0	8	12

MEDIUM SPEED, HORIZONTAL SIDE CRANK TANDEM COMPOUND ENGINES.

Horse-power at 100 lbs. Non-Condensing.	Cylinders.			Revolutions per Minute.	Standard Wheel.	Width of Belt, Inches.	Floor Space.		Diam. of Pipes.	
	Diameters.		Stroke, Inches.		Diameter, Inches.		Length, Ft. In.	Width, Ft. In.	Steam, Inches.	Exhaust, Inches.
	High P. Inches.	Low P. Inches.								
335	16	28	22	180	120	22	24—0	13—0	6	14
335	16	28	24	165	120	22	24—0	13—0	6	14
385	18	30	22	180	120	26	24—0	14—0	6	14
385	18	30	24	165	120	26	24—0	14—0	6	14

VERTICAL SINGLE-CYLINDER ENGINES.

Horse-power.			Cylinders.		Revolutions per Minute.	Standard Wheel.	Width of Belt, Inches.	Floor Space.		Diam. of Pipes.	
80 Pounds.	90 Pounds.	100 Pounds.	Diameter, Inches.	Stroke, Inches.		Diameter, Inches.		Length, Ft. In.	Width, Ft. In.	Steam, Inches.	Exhaust, Inches.
56	63	70	10	12	300	48	10	5—0	4—0	3½	5
70	78	86	11	12	300	54	10	5—0	4—6	3½	5
82	92	103	12	12	300	54	10	5—6	4—6	4	6
97	109	121	13	12	300	60	12	6—0	5—0	4½	6
112	126	140	14	12	300	60	12	6—0	5—0	4½	7
132	149	165	15	14	265	66	14	7—0	5—6	5	7
156	175	195	16	16	240	72	14	7—6	6—0	6	8
176	198	220	17	16	240	72	14	7—6	6—0	6	8
203	229	255	18	18	220	72	16	7—6	6—0	6	9

VERTICAL CROSS COMPOUND ENGINES.

Horse-power at 100 lbs. Non-condensing.	Cylinders.			Revolutions per Minute.	Standard Wheel.	Width of Belt, Inches.	Floor Space.		Diam. of Pipes.	
	Diameters.		Stroke, Inches.		Diameter, Inches.		Length, Ft. In.	Width, Ft. In.	Steam, Inches.	Exhaust, Inches.
	High P. Inches.	Low P. Inches.								
115	10	18	12	300	60	12	7—0	5—0	4	9
135	11	19	12	300	60	12	7—0	5—0	4½	9
150	12	20	12	300	60	12	7—0	5—0	4½	9
190	13	22	12	300	66	12	7—6	5—6	5	10
250	15	25	14	265	72	14	8—9	6—0	6	12
325	16	28	16	240	80	16	9—8	7—6	6	14
335	16	28	18	220	84	18	9—8	7—8	6	14
385	18	30	18	220	84	18	10—0	8—0	6	14

CONTENTS.

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